STATURE ESTIMATION FROM HAND LENGTH AND FOOT LENGTH IN ADULTS – A REGIONAL STUDY IN CHENNAI, TAMILNADU.

Dissertation submitted to **THE TAMILNADU Dr. M.G.R.MEDICAL UNIVERSITY** in partial fulfillment for the award of the degree of

DOCTOR OF MEDICINE IN FORENSIC MEDICINE

Branch XIV

INSTITUTE OF FORENSIC MEDICINE

MADRAS MEDICAL COLLEGE

CHENNAI - 600 003

March, 2008

CERTIFICATE

This is to certify that the dissertation entitled, **"Stature estimation from hand length and foot length in adults – A regional study in Chennai, Tamilnadu"** submitted by **Dr.K.S.M.Venkatachalam,** in partial fulfillment for the award of the degree of Doctor of Medicine in Forensic Medicine by the Tamilnadu Dr. M.G.R. Medical University, Chennai is a bonafide record of the work done by him in the Institute of Forensic Medicine, Madras Medical College, during the academic year 2005 – 2008.

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ACKNOWLEDGEMENT

At the outset, I thank the souls which the God has provided me for this study. I pray for the souls to rest in peace.

I am greatly obliged to the **Dean**, **Dr. T.P. Kalanithi MD,** Madras Medical College and Government general hospital for allowing me to conduct this study by utilizing the patients as my study subjects.

I immensely thank our **Director and professor** of Forensic Medicine **Dr. R. Vallinayagam MD**. for his expert guidance in bringing out this dissertation for my M.D. exam.

I thank **professor** of Forensic Medicine **Dr. P. Ravisankar MD, DHA.** Presently Dean, Govt. Medical College, Tiruchirapalli for his kind suggestion in executing this project.

I also thank Director and professor of Internal medicine **Dr. Thirumalaikolundu Subramanian MD.,** for his novel ideas in designing the study protocol.

I am thankful to **Dr. R. Selvakumar, MD.,** Reader in forensic medicine for his guidance to this study.

I am very much proud to acknowledge my humble gratitude to **Dr. N.Srinivasa Ragavan. MD., PGDMLE.,** Assistant professor of Forensic Medicine for his constant encouragement and ideas throughout this work and for giving me full hope and confidence to complete this study in a successful manner.

My very special thanks to my father-in-law **Mr. R. Arumugam,** Proprietor Arbaa Industries, Kumbakonam, for making instruments for my study.

I am very grateful to **Dr. A. John William Felix M.Sc., Dip. S.A.D.P. PhD.** selection grade lecturer cum statistician, Annamalai University, for his fine statistical analysis and presentation.

I also thank **Mr. J. John Jeyasekar B.Sc., MLIS, Dip.in French**, Librarian of Forensic Science Laboratory, Chennai for helping me in collecting all the literature for my study.

I am greatly indebted to my cousin **Mr. P. Manikandan M.Sc., MBA, M.phil** for his continuous help day and night, in data processing, DTP work and finalizing this manuscript.

I thank **Mr. T. Thirumoorthy B.com. DCA**. Junior Assistant, Annanmalai University for making all the electronic typing work for my study.

I thank all my **colleagues** and **students** for helping in collecting data for my project.

Last but not least, I would like to pay my gratitude to my **spouse** and **sons** for their prayer and patience in carrying out this dissertation.

ABBREVIATIONS

a.m.	- ante meridian
C2	- 2nd Cervical Vertebra
cm.	- Centimeter
C-H	- Crown Heel
C-R	- Crown Rump
Dr.	- Doctor
F	- Female / Femur
F.H. Plane	- Frankfort Horizontal Plane
Govt.	- Government
H	- Humerus
HSC	- Higher Secondary Course
i.e.	- That is.
L5	- 5th Lumbar Vertebra
LH	- Left Hand
LHL	- Left Hand Length
LF	- Left Foot
LFL	- Left Foot Length
M	- Male
Max.	- Maximum
M.F.	- Multiplication Factor
Min.	- Minimum
mm.	- Mille meter
No.	- Number
P	- Probability value
PP	- Page No.

r	- Pearson correlation co-efficient
R	- Multiple correlation co-efficient / Radius
R^2	- co-efficient of determination
RH	- Right Hand
RF	- Right Foot
RHL	- Right Hand Length
RFL	- Right Foot Length
S1	- 1^{st} Segment of Sacrum.
S	- Stature
Sl.	- Serial
SE	- Standard Error
SEE	- Standard error of estimate
SPSS	- Statistical Product and Service Solution (a software)
SSLC	- Secondary School Leaving Certificate
t	- Student's't' test
T	- Tibia

Introduction

SECTION – I

INTRODUCTION

Identification is necessary in living persons, recently dead persons, decomposed bodies, mutilated bodies and skeleton. The police have to establish the identity of a person. If the victim's identity is not known, it becomes difficult for the police to solve the crime.[1]

Visual identification becomes difficult or impossible in cases of fires, explosions, advanced decomposition, mutilation, aircraft accidents, earthquakes, mass disasters and other terrorist activities.[1] Identification of individual by stature estimation has thrown a great degree of challenge to the forensic experts after the earthquake in Turkey in August 1999, the terror attack on the World Traders Centre in United States and the mass casualties reported during Tsunami in December 2005.

The main part of corpus delicti (i.e. the body of the offence; the essence of crime) is the establishment of the identity of the dead body.[1] Identification of dead body and proof of corpus delicti is essential and integral part of any criminal and civil justice delivery system throughout the world.

The three primary characteristics of identification of a person are Sex, Age and Stature.[1] The stature prediction occupies relatively a central position both in the anthropological research and in the identification necessitated by the medical jurisprudence or by medicolegal experts.[2] Estimation of stature of an individual from the skeletal remains or from the

mutilated or amputated limbs or parts of limbs has obvious significance in the field of forensic anthropology.

Studies on the estimation of stature, mostly of the long bones have been reported as indicated by the published work of Karl Pearson (1899), Dupuertuis and Hadden (1951), Trotter and Glesser (1952). The Indian perspective of the problem of stature estimation has been studied by Pan (1924), Nat (1931), Siddiqui and Shaw (1944), Athwale et al (1963), Patel et al (1964), Joshi et al (1964, 1965), Lal and Lala (1972), Kalte and Bausal (1974), Thakur and Rai (1987), Saxena (1984), Bhatnagar et al (1984), Jasuja (1987), Jasuja et al (1991, 1993, 1997).[2]

There are lot of international and regional level studies regarding the stature estimation and other aspects of identification from various body parts. A mere superficial perusal of the various studies regarding the stature estimation clearly indicates that there is wide and distinct variation from country to country, region to region and place to place. Hence this study of stature by hand and foot length specific to our region (Chennai, Tamil Nadu) assumes great deal of importance and interest.

In the presence study an attempt has been made, which is first of its kind in Tamilnadu, to estimate the stature of an adult individual of either sex not only from hand length, foot length but also from a variety of combination of both hand and foot lengths of either sides. In this regional study multiplication factors also have been derived to estimate stature from hand length and foot length for both sexes.

Study objectives

SECTION – II

STUDY OBJECTIVES

1) To find the correlation of stature with hand length, foot length and its various combinations in adult individuals.

2) To find out sexual variations in determining this correlation.

3) Making multiple regression formulas and simple regression formulas for stature estimation of both sexes from

   i) Right Hand Length, Left Hand Length, Right Foot Length and Left Foot Length – using all four selected variables.

   ii) Right Hand Length and Right Foot Length

   iii) Left Hand Length and Left Foot Length

   iv) Right Hand Length and Left Foot Length

   v) Left Hand Length and Right Foot Length

   vi) Right Hand Length alone

   vii) Left Hand Length alone

   viii) Right Foot Length alone

ix) Left Foot Length alone

4) To find out multiplication factors for hand length, foot length to estimate stature in both sexes separately.

Review of literature

SECTION – III

REVIEW OF LITERATURE

Stature

By stature we mean body height or body length of a person[3]. It is an important criterion for identification of a person. Identity of a person is incomplete without mentioning his/her height. [4]

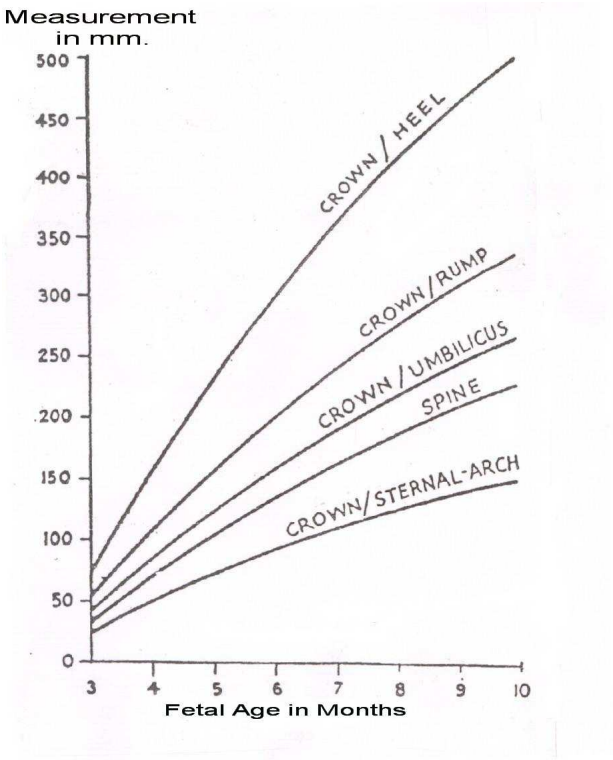
Growth pattern – Conception to adulthood

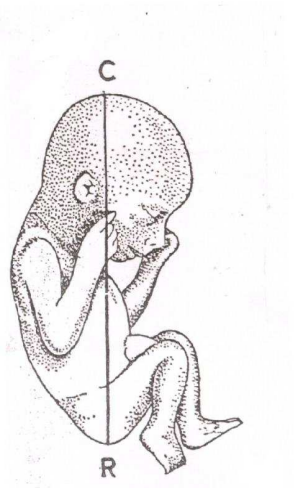
Starting from the intra-uterine life, stature increases up to 20-21 years of age of a person. After this age, though not of much significance, it slightly reduces with further increase of age.[3] Both malnutrition and advancing years reduce stature. After the age of thirty, the natural processes of senile degeneration cause gradual decrease in stature by about 0.6 mm. per year on an average[1]. Morant (1950) has shown that after reaching its maximum, stature falls about 2.5 cm. for every twenty-five years and Trotter and Gleser (1953) suggest subtracting 0.06 cm. for each year in age over thirty. [5, 6]

There are a number of formulas for estimating fetal age from measurement of crown-heel length (C-H length) or crown-rump length (C-R length). The useful ones are given below.

1. C-R length and fetal age: The embryo is 5 mm. in C-R length at thirty two days; it grows about 1 mm. a day up to the fifty fifth day, when it is 28-30 mm. in C-R length; after the fifty fifth day the C-R length increases by about 1.5 mm a day until term.[5]

2. C-H length and fetal age **Rule of Haase (1895)**: This is rough method of calculating the age of the fetus. The length of the fetus is measured from the crown to the heel in centimeters. During the first five months of pregnancy, the square root of the length in cm. gives the approximate age of the fetus in months. During the last five months, the length in cm. divided by five gives the age in months. [1]



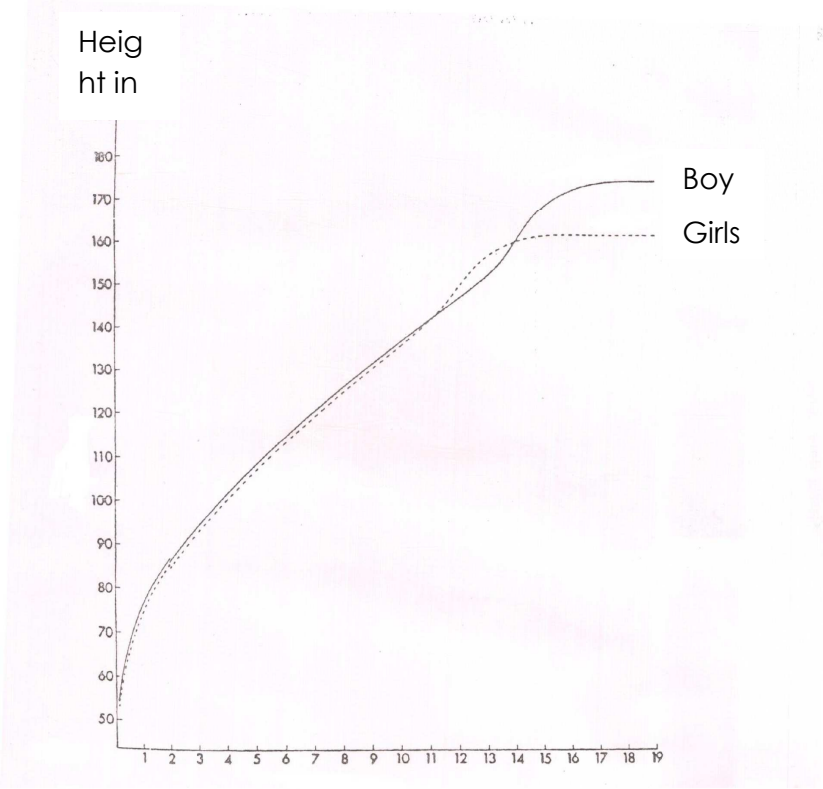


Method of measuring Crown-Rump (C-R) length of a fetus

Method of calculating Fetal Age by various parameters

On an average, ideal length of a full-term baby at birth is 50 cm. It rises to 60 cm at 3 months, 70 cm at 9 months, 75 cm at one year, 85 cm at 2 years, 95 cm at 3 years and 100 cm at 4 years[7]. Thereafter, the child gains little over 5 cm every year until the age of 10 years. After this, increments in height vary according to the age at the onset of puberty. There is a marked acceleration of the growth during puberty.[8]

On an average, adolescent growth spurt occurs at 10 to 12 years in girls and 12 to 13 years in boys. Growth in stature generally extends up to 16 to 17 years in girls and 18 years in boys.



Growth curves comparison between Boys and Girls[9]

The maximum stature (at least in American men) was found in 1951 to be reached at the age of 23 year, a change from earlier estimates peak was found to occur between 18 – 21 years of age.[6]

Adolescent boys and girls gain about 25 percent of the adult height and 50 percent of the adult weight during puberty. The age of onset and the rate of pubertal development show a wide variation. With the pubertal spurt, boys tend to become more muscular and girls show fat deposition in characteristic female distribution. Growth spurt occurs in three phases. **Phase 1:** There is a moderate increase in height velocity in the prepubescent phase.

Phase 2: In the pubescent phase, both height and weight increase rapidly. **Phase 3:** In the post pubescent phase the velocity of growth decelerates, but the weight gain continues even after the increase in the height stops due to epiphyseal fusion[8].

Body Ratios[7]

Upper / lower segments ratio (as measured from the pubis) at birth is 1.7:1. With the greater increase in the length of the legs compared to the trunk, by the age of 10 to 12 years the ratio becomes approximately 1:1.

Stem stature index refers to the sitting height (crown-rump length) as percentage of the total height or recumbent length. It is 70 at birth, 66 at 6 months, 64 at 1 year, 61 at 2 years, 58 at 3 years, 55 at 5 years, 52 at puberty and 53 to 54 at 20 years.

Span is the distance between tips of middle fingers when the arms are outstretched. It is equal to height at 10 years. In earlier years, it is 1 to 2 cm less than the length / height. After 12 years, it is 1 to 2 cm. more than height.

Classification of Adult person by Stature[10]

According to Schmidt		Adult height classification	According to Martin	
Male(cm)	Female(cm)		Male (cm)	Female (cm)
169	-	Median	165	154
-	-	Pygmies	≤129.9	≤120.9
≤152.9	≤141.9	Very short	130 – 149.9	121 – 139.9
153 - 162.9	142 – 150.9	Short	150 – 159.9	140 – 148.9
163 – 166.9	151 – 154.9	Lower medium	160 – 163.9	149 – 152.9
167 – 169.9	155 – 157.9	Medium	164 – 166.9	153 – 155.9
170 – 172.9	158 – 159.9	Upper medium	167 – 169.9	156 – 158.9
173 – 182.9	160 – 169.9	Tall	170 – 179.9	159 – 167.9
183 – 203.9	170 – 188.9	Very Tall	180 – 199.9	168 – 186.9
≥ 240	≥189	Giants	≥ 200	≥187

Stature variation[3]

Stature is more[3]

1. It is maximum between 20 – 25 years of age of a person.
2. It is more during morning hours of the day.
3. It is more in the recumbent position (1 – 3 cm)
4. It is more in dead bodies during the stage of primary relaxation (up to 1.5 cm in males and 2 cm. in females).[6]

Stature is less

1. After the age of 25 years, it decreases about 1 mm. per year.
2. During the evening hours, the stature of a person may be about 1.5 cm. less than what it is in the morning hours. This is due to decreased elasticity and increased tonicity of the vertebral muscles in the evening.
3. In standing posture, the stature is slightly less than what it is in the recumbent position.
4. In reduces drastically while the person takes heavy load on his head.[11]
5. In a dead body, the length reduces during the stage of rigor mortis.

Determination of stature

If the body has been dismembered, the approximate stature may be determined by

1. The length from the tip of the middle finger to the tip of the opposite middle finger, when arms are fully extended laterally in a horizontal position away from the body, closely equals the height [1,3,4,12,13,14,15,16,17,18]

2. The length from the vertex to the symphysis pubis is roughly half of stature. After 14 years of age the symphysis pubis lies about halfway up the body. Before 14 years the trunk is longer than the lower limbs[1,3,4,12,13,14,15,16,17,18,19,20,21].

   From the vertex of the skull to the symphysis pubis is not always one half of the height, it some time exceeds by two inches.[18]

   The pubic symphysis lies at the center of the body at 20-25 year till life[16,17].

3. Twice the length of one arm, with 30 cm. added for two clavicles, and four cm. for the sternum, is equal to the height. [1,3,4,13,14,15,16,17,18,19,21]

4. The length from the sternal notch to symphysis pubis multiplied by 3.3 gives the stature (i.e. 1/3 of stature) [1, 3,4,13,14,17,19].

5. The length of forearm measured from tip of olecranon process to tip of the middle finger is equal to 5 /19 of the stature (i.e. stature is 3.7 times of cubit length) [1,12,13,14,15,16,17,19].

6. i. The height of head measured by the vertical distance from the top of the head to the tip of the chin is about 1/7 of the total height. [1,14,17]

   ii. The height of the head is 1/8 of the stature [13, 19] .

7. The length of skull is about 1/8 of the total height. [1,15,16,17,20] .

   The often quoted rule that the length of the body is the same as the width between the outstretched arms is quite inaccurate. The rule that "eight times the length of head in equal to the height of the body" is patently nonsense, as there is great variation in the ratio of head size to body size. [22]

8. The length of vertebral column is 35/100 of the height[1,13,14].

9. To the length of entire skeleton add two and half cm. to four cm for the thickness of the soft parts[1,3,4,12,13,15,16,17,19,20,23,24].

10. Maximum foot length divided by 0.15 gives stature[1,14].

11. From the base of the skull to the os coccyx is about 44 percent of the height.[18]

12. A useful rule of thumb is that the humerus is 20%, in tibia 22%, the femur 27%, and the spine is 35% of the individual's height in life.[1,22,25]

13. Multiplication factor = Average height (stature) of the body / Average length of long bone or Body part.

    Therefore, Stature = Average length of long bone or body part x M.F.

    Multiplication factor for different bones are [26]

Bones	Multiplication factor
Femur	3.7
Tibia	4.5
Humerus	5.3

Radius	6.5

The multiplication factor for estimation of stature from Clavicle worked out to be 11.1 from a study at East Punjab by Singh and Sohal.[16]

Factors Affecting Multiplication Factor[4]

The multiplication factors vary and depend on various factors, such as:

Sex – varies in male and female

Age – varies in adults and children

Bones – varies from one long bone to another long bone

Type of bone – varies for wet and dry bones

Race – varies from race to race

14. The following table for height estimation found very useful.[23]

Height Estimation

Osteological data showing ratios of principal measurements to total height, expressed in percentages.

Age	Birth	2 yrs.	4-6 yrs.	8-12 yrs.	15 yrs.	18-19 yrs.	Adult
Height	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Spine	36.84	31.48	33.71	29.76	30.74	30.83	34.15
Head circumference	79.00	65.55	51.42	43.72	35.70	33.00	31.54
Humerus	18.50	17.40	18.85	19.30	19.25	19.00	19.54
Radius	13.20	13.33	13.71	14.09	13.70	14.33	14.15

Hand	16.30	11.48	11.71	11.86	10.55	11.11	11.23
Femur	22.00	22.94	26.00	26.51	27.40	26.38	27.51
Tibia	18.50	18.88	20.28	21.86	21.48	22.16	22.15
Foot	18.50	13.33	14.57	14.65	14.81	13.83	16.03
Transvers diameter of pelivs	6.80	8.14	7.14	7.21	7.03	7.83	8.00
Anterio – posterior diameter of pelivs	6.80	8.14	7.14	7.21	6.66	7.50	6.61

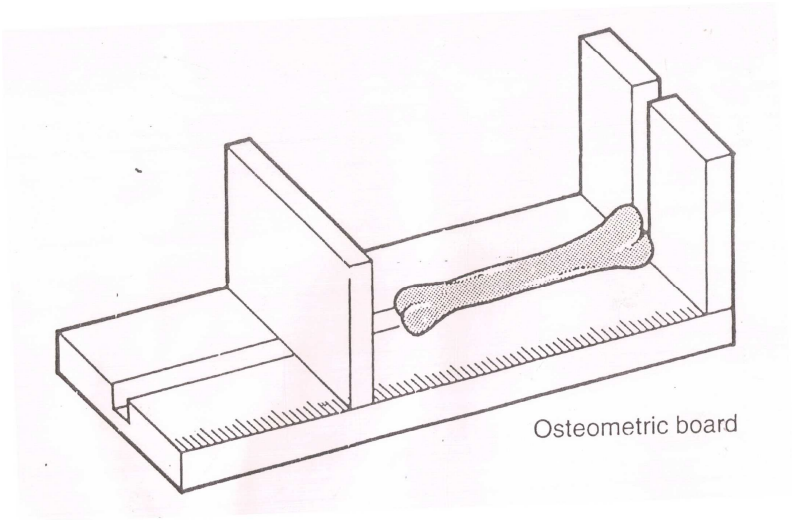
In assembling parts of a body with a view to direct measurement, it is necessary to arrange the parts in their correct and natural positions as securely as possible so that the measurement of the reconstructed body may be determined accurately. After measurement, a small deduction of 1.25 cm. from the male and 2 cm. from the female length, the amount by which, on the average, the body lengthens after death, should be made in order to arrive at the probable living stature.[27]

Measurement of long bones

Long bones must be measured in the proper manner which involves the use of a Hepburn-type osteometric board; measurements made by the use of tapes, calipers, string or other methods are suspect.[5] To maintain a uniform standard, some authors have recommended use of right side bones only.[3]

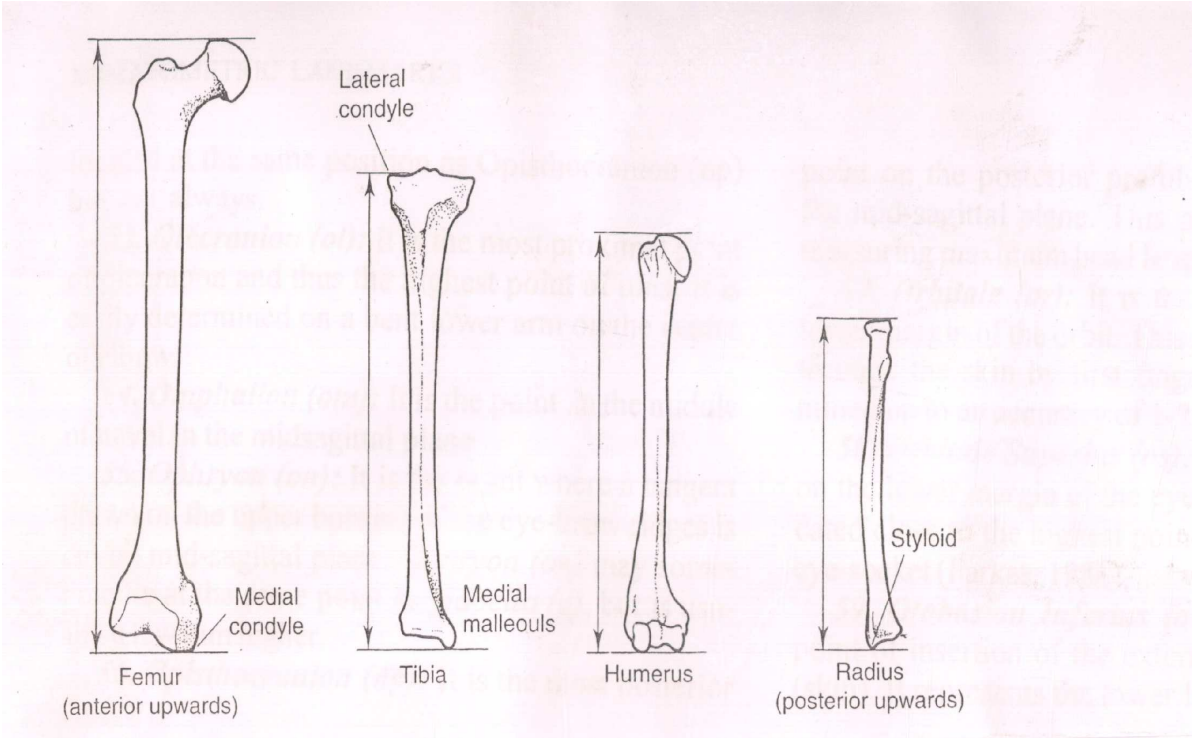
The manner in which these bones should be measured was agreed at an international meeting of anthropologists in Geneva at the turn of the 20th century. “For the reconstruction of the stature with the aid of long bones, the maximum length shall be measured in all cases, except in those of the femur and tibia where the length measured in oblique position is taken”.[23]

Osteometric board[1]: This has a rectangular base with a ruler fixed along one of its long sides. An upright is fixed at one end of the board, and a second one slides along the board. The bone is placed with one of its ends against the fixed upright and the movable upright is brought up to the other end of the bone. The distance between the uprights is then shown on the ruler. **Hepburn osteometric board modified by Trevor** is commonly used.



Measurements of femur, tibia, humerus and radius are useful. Long bone lengths are measured as follows:

1. Femur : Head to medical condyle.
2. Tibia : Lateral condyle to tip of medial malleolus.
3. Fibula : Tip of head to tip of lateral malleous
4. Radius : Medial margin of head to tip of styloid process.
5. Ulna : Top of head to tip of styloid process.
6. Humerus : Trochlea to the head.



Dimensions of dried bones for estimations of stature

In the absence of long bones, adult stature can be calculated from the articular length of the five metacarpals.[1]

Anthropometry[10]

Anthropometry – the measurement of man – provides scientific methods and techniques for taking various measurements and observations on the living man and the skeleton.

The origins of anthropometry are very ancient. The word anthropometry was first used in the 17th century by a German physician, J. Sigismund Elshwltz (1623-88) for his graduation thesis entitled “Authropometria”.

Broca in 1875 published a paper containing instruction regarding craniometry and craniology. He detailed methods of collecting and preserving weak and brittle bones. He also defined the measurement, landmarks to be used as well as the instrument required in taking them. His methods were widely used by anthropologist.

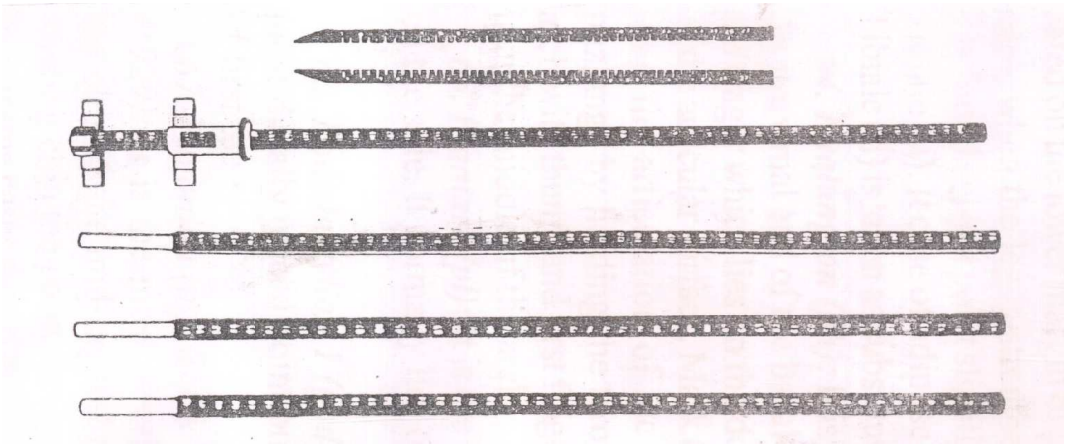
Anthropometry can be sub-divided into the following sections:

1. **Osteometry**:- measurements of skeleton
    a. **Craniometry**:- measurements of skull
        i. **Odontometry**:-measurements of teeth
    b. **Measurements of the post-cranial skeleton**
2. **Somatometry**:- Measurements of the body i.e. the outermost measurements of the living or dead body.
    a. **Measurements of the total and post-cephalic body**.
    b. **Cephalometry**:- Measurement of the head.

Instruments:

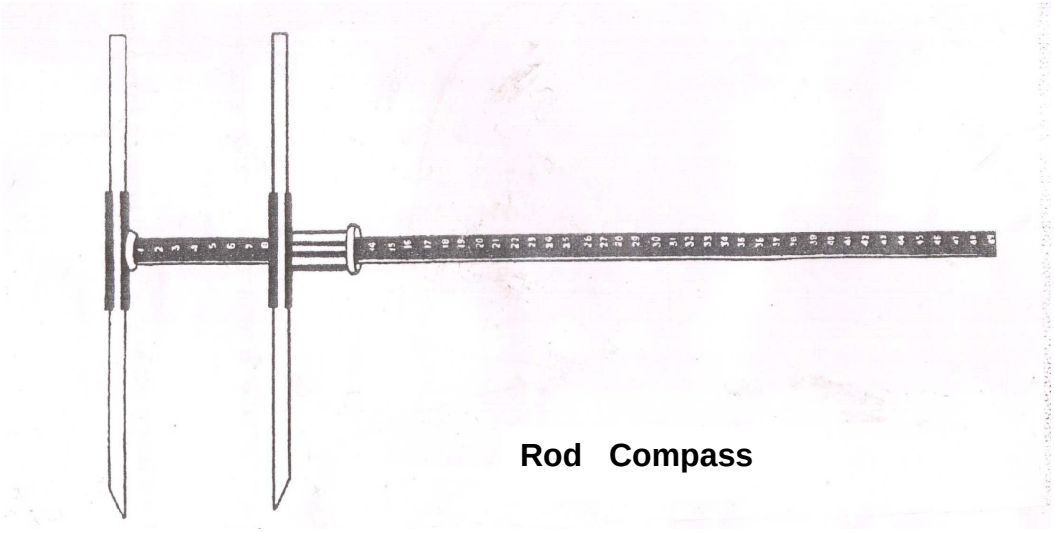
A number of instruments have been devised by anthropologists for taking accurate measurements on the living as well as on the skeleton.

Anthropometer Rod: It is the most used instrument for many of the anthropometric measurements on the living. It is used to take height measurement as well as transverse breadths of the body. It consisits of four segments which when joined together form a rigid rod of 200 cm.



Anthropometer Rod: Four Segments with Cross Bar.

Rod Compass: The first segment of the anthropometer can be used as a large sliding caliper by adjusting the cross rods for taking breadth measurements.



Rod Compass

Osteometry[10]:

The difference in the length of the living and skeletal long bones is because of drying up and the thickness of the cartilaginous joints. This varies between approximately 3.2 mm in radius to 7.1 mm in femur according to Martin and Saller (1957). The shrinkage is much greater in case of the newborns. The shrinkage of the upper and lower epiphysis is up to 25 percent of the total length of the bone. The shrinking is also greater in children. In adults the water content is replaced by minerals and the epiphysis become thinner.

The difference in the length of different long bones of the living and skeleton because of loss of water and drying up is as follows.

Femur	-	2.3 – 2.6 mm.
Tibia	-	1.7 mm.
Humerus	-	1.3 mm.
Radius	-	0.7 mm.

The cartilaginous joints also completely disappear in skeleton and the average thickness of the upper and lower joints taken together for various long bones are;

Femur	-	4.5 mm.
Tibia	-	4.5 mm.
Humerus	-	2.8 mm.
Radius	-	2.5 mm.

In the skull all major dimensions are reduced by 1-2% by drying. In the vertebral column, total length is reduced by 2.7% by drying.[1]

Boyd and Trevor (1953) advise the subtraction of the following figures from the length of the bones if they are in a more recent condition with their cartilage intact: femur – subtract 7mm, tibia – subtract 5mm, humerus – subtract 5mm., radius – subtract 3mm.[5]

Somatometry:

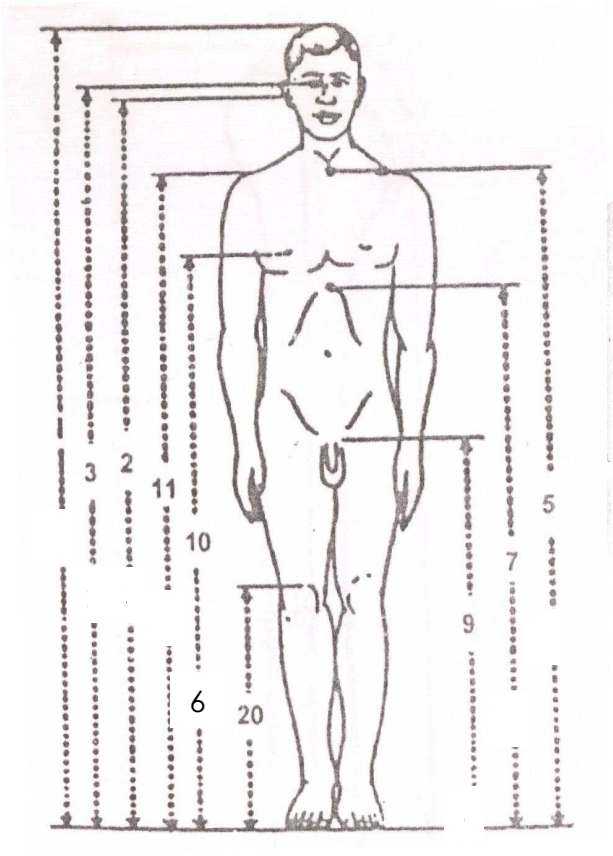
Somatometric techniques: measurements of the body should be taken with the minimum number of clothes. The subject should stand erect barefoot on a level floor against the wall with his back and hips touching the wall, the feet should run parallel to each other and the heals must touch the wall. The shoulders should not be raised upwards. Arms should hang to the maximum and the palms of the hand should touch the thighs. Note that there is enough light on both the subject and the instrument. The head of the subject should rest without any strain in the eye-ear plane / Frankfurt horizontal plane.

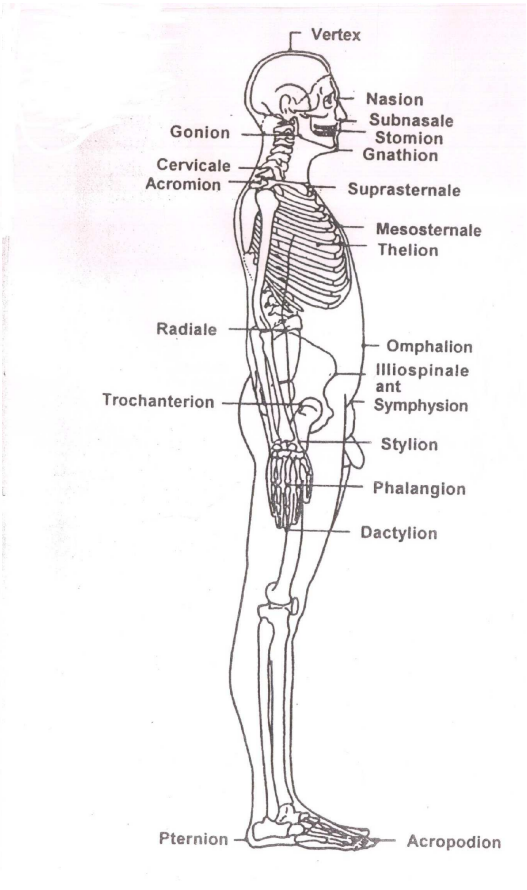
Frankfurt plane: Line between lower border of orbit and the porion of external auditory meatus.

Porion: The upper most and outer most point of bony external auditory meatus.

Personal errors may be allowed to a certain extent. Martin recommends that for head measurements an error of 0.5 – 1.0 mm.; for head height 2.0 mm.;

for most of the body measurements 3.0- 5.0mm. and for stature and span 10.0mm. may be allowed.





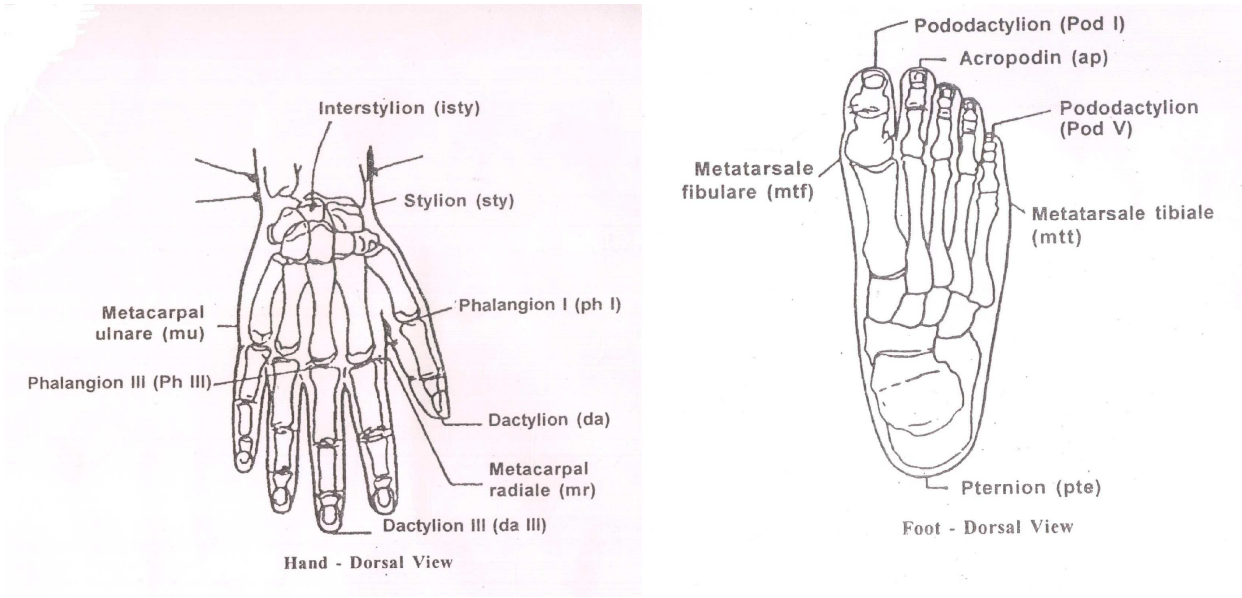
Somatometric Measurement – Height Measurement of the Body in Standing Position[10]

Somatometric Landmarks Human Body – Lateral View[10]

1. ***Height vertex***: Vertex to Sole (Floor)
2. ***Eye height***: Inner corner of right eye to Sole (Floor)
3. ***Height tragus***: Tragus of ear to Sole (Floor)
4. ***Shoulder height*** : Acromion to Sole (Floor)

5. ***Height Suprasternale***: Suprasternal notch to Sole (Floor)
6. ***Nipple height***: Right nipple to Sole (Floor)
7. ***Height Substernale***: Substernal to Sole (Floor)
8. ***Height Symphysion***: Symphysion to Sole (Floor)

   Symphysion-Upper edge of the junction of the penis with abdomen.
9. ***Knee height***: Upper most point of patella to Sole (Floor)



Somatometric Landmarks: Dorsal View of Human Hand and Foot[10]

Methods of estimating stature from the skeleton[11]

The source materials for developing methods for stature estimation from the skeleton differ in character. They are of three basic types.

1) Collections of cadavers where cadaver lengths have been measured before and bone measurements taken after maceration. It had already been observed by the end of the nineteenth century that the length of the cadaver tended to be about 2.5 cm longer than the actual stature of the individual when living. This is explained by the relaxation of ligaments and vertebral disks as well as a flattening of the vertebral disks as well as a flattening of the vertebral curvature after rigor mortis. This means that the bone measurements are exact, but stature has to be subtracted because of the extension of the corpse as well as corrections because of reduction due to age.

2) Collections of living individuals where stature is known but the bone lengths have to be estimated from corresponding somatometric measurements on the body. In this case, it is possible to select the material so that reduction of stature due to age is eliminated. Thus, in these cases stature is known, but the bone lengths have to be estimated. The advantage of such a method is that large samples may be collected by measurement of individuals according to the same protocol, the disadvantage is the errors introduced when bone lengths are estimated.

3) Collections of individuals where both statures when living as well as bone lengths after death are known. These are considered ideal if it

is not influenced by older individuals whose statures have been reduced due to age.

Four different principles have been applied for stature estimation from the skeleton.

1) The apparently most simple is based on crude ratios between the stature and the skeletal measurements, because for every individual the stature may be expressed by the skeletal measurement multiplied by a certain factor. So far, however, the actual standard errors connected with the use of crude factors have not been calculated. The errors made therefore remain unknown, which is a disadvantage of the method.

2) The second principle is based upon regression equations, either as simple regression equations, when the stature is estimated from one bone measurement, or multiple regression equations, when the stature is estimated from several measurements simultaneously. Simple regression is a method in which the stature is calculated as a produce of the bone measurement and a factor plus a constant term. Multiple regressions involve differential weighting of the bone measurements used which means that the factors with which to multiply each of the bone measurements are differentiated according to the importance of the measurement. The stature is calculated as the sum of products of each measurement and individual factors plus a constant term. All factors and constant terms are mathematically determined from a source material where both stature and bone

measurements are known according to one of three types of source materials. For this process **least – squares simple regression** is used. This is a mathematical method that minimizes the standard error of the stature estimate, and from that point of view this is the best choice for estimating stature.

3) The third principle aims at reproducing correctly the stature of the tallest and the shortest individuals, at the cost of a slightly higher standard error. This kind of method has, so far, only been developed for situations comparable to simple regression, estimates of stature based on the measurement of one bone at a time. It is related to least – squares regressions. The method, known as the **reduced major axis method**, minimizes the sum of products of the deviation between actual and estimated stature and corresponding actual and estimated bone measurements in the source material. This kind of equation may also well be used in order to estimate the bone measurement from the stature, whereas this is not even possible for simple regression, because another regression equation is needed.

4) The fourth principle is called the anatomical method. It is based on the sum of measurements of the skull height, the individual vertebrae of the vertebral column, femur, tibia, talus and calcaneus in articulated position, to which estimates of missing soft tissue are added, depending on the sum of the measurements.

Forensic Anthropology in relation with stature reconstruction[28]

No other identification procedure used by forensic anthropologists has undergone such a complicated course of development involving so many identifiable contributors as that concerned with the estimation of stature from more or less detached parts of the skeleton.[28] When a full skeleton is available, then obviously direct measurement of the correctly assembled bones will give the original height within a few centimeters. When incomplete skeletal material is available, calculations have to be made on the basis of one or more bones. Where possible, all available bones should be used and a consensus results assessed, though the accuracy derived from different bones varies and the result from – say, a femur – is more reliable than that from an ulna. The descending order of usefulness is: femur, tibia, humerus , radius.[6]

History[28]

Thomos Dwight (1894) proposed two different methods of stature reconstruction namely 1) anatomical method 2) mathematical method. In his words,

"The mathematical method rests on the proportion of certain bones to the height….. There are persons with short legs and persons with long legs, and therefore no single rule of proportion can be true for both. This method therefore, is to be used when we can do no better.

The anatomical method consists simply in putting the bones together, in reproducing the curves of the spine, in making due allowance for the soft parts, and in measuring the height.**"**

If it is a matter of finding the closest possible estimate in a particular case, the anatomical method should yield it. On the other hand, for most purposes, application of the mathematical method will suffice.

Mathematical method

Sue to Topinard:

Jean Joseph Sue (**1710-1792),** an anatomy professor at the Louvre, France published in 1755 four body measurements and the maximum length of many of the bones of fourteen cadavers, ranging in age from a six-week-old fetus to an adult of twenty-five years. The body measurements – stature, trunk length, upper-extremity length, and lower extremity length – provided perhaps the first clear documentation of two important facts concerning change in body proportions during growth, namely, (1) that the length of the trunk exceeds that of the lower extremities until about fourteen years of age, after which both lengths are equal (in other words, after fourteen the pubic symphysis is usually the center of body length) and (2) that the length of the upper extremities exceeds that of the lower extremities until about birth, after which the lower extremities are the longer. Sue said little about how the measurements were taken, but clearly indicated that the units of measure were the *pied* (foot), *pouce* (thumb or inch), and *ligne* (line, 12 to the inch). His purpose in publishing the measurements was to provide artists with a means of rendering the human body in correct proportions.

Matthieu Joseph Bonaventure Orfila (1787-1853), a professor of legal medicine in Paris, brought Sue's measurements to wider attention in two medicolegal textbooks (1821-23, 1831). Also, in these books he followed Sue's

example and reported the same selection of measurements for his own series of fifty one cadavers and twenty skeletons. He departed from Sue's example only in using the metric units of measure. In order to determine the stature of a skeleton from the measurements of Sue and Orfila one needed to measure the length of one or more bones, say a femur and / or a humerus, then find in the tables comparable bone lengths and note the corresponding cadavers statures.

Soon the authors of other medicolegal textbooks picked up the Sue – Orfila measurements. In the United States one of the earliest to do so was **T.R.Beck (1823).**

In Britain early in the ninettenth century much efforts was being expended on determining the statures of the ancient races of that country. Consequently the British anthropologiest appear to have taken as much interest in the Sue – Orfila measurements as did the British medicolegal experts. **John Thurnam (1810-1873), Sir George Humphry (1820-1896),** and **John Beddoe (1826-1911)** in particular combined the Sue-Orfila measurements with their own to investigate the relationship of long-bone lengths to stature. While differing from the French methods of stature estimation, the British methods had in common an adjustment of femur length and the multiplication of this length by a given number. Beddoe's description of his own method for male person provides a good example. **"**I take away from the length of the femur one quarter of the excess over 13 inches up to 19, and thereafter only one-eighth; and then multiply by four**"**. Note: Substitute 12 for 13 and 17.5 for 19 in case of female for the above description.[29]

While this was going on in Britain, the French anthropologists were still active**. Paul Broca (1824-1880),** a medical anthropologist, founded the ***Societe d anthropologie de Paris*** **in 1859** and, among many other things, introduced the **osteometric board** for measuring long-bone length more accurately. Then between 1885 and 1888 **Paul Topinard (1830-1911),** Broca's successor as head of the *Societe,* published papers discrediting the procedures being used in Britain, giving a method of his own, and appealing for skeletal data collected according to recommendations he set forth.

By combining his own data with those of Orfila and Humphry, Topinard by 1888 had measurements on a series of 141 skeletons with which he showed that for the combined sexes the following average long bone stature (=100) ratios held:

Maximum length of humerus	Maximum Length of radius	Maximum length of femur	Maximum length of tibia
20.0	14.3	27.3	22.1

Using these ratios, he offered the following formula for stature estimation

R**:** 100**::** L **:** x ; where R = the relationship of the particular long-bone to stature (=100), L = the length of the bone measured, and x = the stature sought. x = L/R x 100. Add 35 mm and you have the true stature, that of the living.

<u>Rollet to Pearson</u>

Soon after 1885, **Alexander Lacassagne (1853-1924),** the professor of legal medicine in the medical school at Lyon and an active member in the local anthropological society, set one of his students to work measuring the stature and long bones of cadavers from the dissecting room there. **Etienne Rollet**

(1862-1973), was the student; the project was for his doctoral thesis. The latter was published in 1889. Although Rollet had set out to follow Topinard's recommendations about methods of measurement, size of series, age limitations, etc., he succeeded in completing only fifty male and fifty female cadavers instead of the desired 100 of each sex, and fifty one of those studied were over sixty years of age, the recommended upper age limit. Nevertheless, he offered his data in a variety of ways, including tables which enable one to see readily the bone length corresponding to a particular stature and *vice-versa*.

Almost immediately (1893) **Leonce Manouvrier (1850-1927),** Topinard's successor as the leader of anthropology in Paris, having taken exception to the way in which Rollet had developed and organized his tables, published his own version which thereafter, owing to Manouvrier's prestige, along was widely used. The following comparison of sample from both men's tables shows the nature of the differences, namely in Rollet's case, the average lengths of long bones from cadavers of the same length, and in Manouvrier's case, the average lengths of cadavers with the same long-bone length.

Rollet, 1989

Male Stature	Lower extremity			Upper extremity		
	Femur	Tibia	Fibula	Humerus	Radius	Ulna
Cm	mm	mm	mm	mm	mm	mm
152	415	334	329	298	223	233
154	421	338	333	302	…	…
156	426	343	…	…	…	…

Manouvier, 1893

Lower extremity			Male Stature	Upper extremity		
Fibula	Tibia	Femur		Humerus	Radius	Ulna

mm	mm	mm	cm	mm	mm	mm
318	319	392	153.0	295	213	227
323	324	398	155.2	298	…	…
328	330	404	157.1	…	…	…

Manouvier also took into account the fact that Rollet had measured the bones while fresh. He included with his tables therefore the recommendation that in using them to determine stature from dried bones, 2 mm be added to the dried – bone length for cartilage loss and that 2 cm be added to the corresponding statures in the tables to convert cadaver stature to living stature.

Manouvrier's tables in turn were superseded, although not as quickly, by a new statistical procedure of the biometric school in England. It is tribute to Rollet, nevertheless, that his detailed skeletal data made possible this further advance. **Karl Pearson (1857-1936),** who was mainly responsible for this advance said at the time (1899) that **"**The only data available for the calculation of the correlation between stature and long bones occur in the measurements made by Dr.Rollet on 100 corpses in the dissercting room at Lyons**"**.

Pearson's approach to stature estimation was based on the regression theory, which involves the calculation of standard deviations for the series of long bones and of coefficients of correlation between the different bones and stature.

It is to be noted in this connection that Pearson not only changed completely the prevailing approach to stature estimation, giving us a more truly "mathematical method," but he departed in other ways from previous practices. Whereas Topinard, like his predecessors, had preferred maximum femur length (Rollet took both maximum and oblique femur lengths) and Manouvrier had

preferred oblique length, Pearson went back to maximum length. And whereas both Topinard and Manouvrier had objected to the inclusion in the cadaver series of individuals over sixty years of age, Pearson saw no reason to omit any of Rollet's aged subjects. Moreover, since Pearson's main reason for entering this field was to continue the traditional British investigation of the statures of ancient races, he produced separate series of regression equations for both fresh and dried bones.

Stevenson to Trotter

Paul Stevenson (1890-1971) was the first to test the general applicability of Pearson's equations. An American trained at Washington University School of Medicine in St. Louis, he served from 1917 to 1937 as Associate Professor of Anatomy at Peking Union Medical College in China. During that time he followed Rollet's procedure of measuring the statures and long-bone lengths of the cadavers in the dissecting room, eventually ending up with data on forty-eight male Chinese, Like Pearson, he used these data to derive regression equations for estimating stature. Surprisingly, his equations did not work successfully with European data, and neither did Pearson's equations work successfully with Chinese data.

Leaving aside **Breitinger's (1937)** contribution to this field because of its very different methodological approach, Manouvrier's tables and Pearson's equations were regarded throughout the early decades of the twentieth century as the only acceptable means to stature estimation.

The next turning point came as a result of the symposium on applied physical anthropology in **1948** where **T.D.Stewart** commented in his paper at

that symposium on the deficiencies of the Rollet data upon which both Manouvrier's tables and Pearson's equations are based, and then said:

"Someone should work up the extensive records of cadaver stature and bone lengths assembled at Western Reserve University and Washington University (St.Louis). We need not only better correlation data for whites, but special data for other races and a better idea of the probable error involved in individual determinations**"**.

As it happened, **Wesley Dupertuis** of Case Western Reserve University and **Mildred Trotter** of Washington University were present at that meeting and acted upon the suggestion within the next few years (**Dupertuis and Hadden, 1951; Trotter and Gleser, 1952**).

Although Dupertuis and Hadden were the first to publish usage of their equations was almost immediately superseded by that of Trotter's and Gleser's equations. Three circumstances mainly were responsible for this 1) Trotter and Gleser had supplemented their cadaver data with the extensive data obtained by Trotter on the young American dead of World War II (Pacific Theater) for which statures measured in life were available 2) they had extended their racial coverage to the Mongoloid war dead; and 3) they had introduced with their equations a correction for age (Trotter and Gleser, 1951).

It is noteworthy, too, that besides producing specific equations for American whites and blacks, Dupertuis and Hadden, ignoring Stevenson's experience, had produced general equations for use on any group.

Trotter and Gleser study

Sources and number of the individuals studied by trotter and glesser[28]

Racial Groups	World war II Males	Korean War Males	Terry collections		Total
			Males	Females	
Whites	710	2817	255	63	3845
Blacks	80	385	360	177	1002
Mongoloids	-	68	-	-	68
Mexicans	-	63	-	-	63
Puerto Ricans	-	49	-	-	49
Total	790	3382	615	240	5027

As Trotter (1970) says **"**There is abundant evidence to indicate that, in general, the most accurate estimate of stature are obtained when the equation applied to the unknown has been derived from a representative sample of the population of the same sex, race, age, geographical area, and time period to which the unknown is believed to belong**"**.

With adult limb bones

Pearson's (1899) regression tables for calculating stature from dried long bones. [6, 29]

Male	Female
S = 81.306 + 1.880 F	S = 72.844 + 1.945 F
S = 70.651 + 2.894 H	S = 71.475 + 2.754 H
S = 78.664 + 3.378 T	S = 74.774 + 2.352 T
S = 85.925 + 3.271 R	S = 81.224 + 3.343 R
S = 71.272 + 1.159 (F + T)	S = 69.154 + 1.126 (F + T)
S = 71.441 + 1.220 F + 1.080 T	S = 69.561 + 1.117 F + 1.125 T
S = 66.855 + 1.730 (H + R)	S = 69.911 + 1.628 (H + R)
S = 69.788 + 2.769 H + 0.195 R	S = 70.542 + 2.582 H + 0.281 R
S = 68.397 + 1.030 F + 1.557 H	S = 67.435 + 1.339 F + 1.027 H
S = 67.049 + 0.913 F + 0.600 T + 1.225 H – 0.187 R	S = 67.467 + 0.782 F + 1.120 T + 1.059 H – 0.711 R

Later in 1894 Thomos Dwight attempted to reconstruct stature from vertebrae by obtaining straight line length of the whole spine (atlas to sacral promontry) and by relating this to body length derived coefficients for both the sexes. These coefficients had great utility for determining the stature of burned remains in which only the spinal column has survived intact.

Male		Female	
Length of spine	Coefficient	Length of spine	Coefficient
cm		cm	
Under 57	2.93	Under 54	2.94
57 to 60	2.84	54 to 57	2.82
60 to 63	2.78	57 to 60	2.79
63 to 66	2.79	Over 60	2.76
Over 66	2.65	-	-

When one has determined the length of the spine in such a case, one locates in the above table the coefficient for the category into which this length falls and multiplies the two. However, Thomos Dwight concluded that **"**While I believe that a typical sternum has a fairly constant ratio to the height in each sex, sternal variations are so numerous that his method must be discarded**"**.[28]

Vertebral segments have been found to be very useful in stature estimation, especially in mutilated human remains; as with other regression formulae, these are population specific and should be adapted to local groups (Jason & Taylor 1995).[30]

Macdonnel (1901) reported on estimation of stature from other measures than long bone lengths. He incorporated finger III length, cubit length (from elbow to tip of the middle finger) and foot length. The estimation formulae formulated by Macdonnel follows as under:[29]

Stature = 166.4572 + 7.7849 (Finger III – 11.5474)

= 166.4572 + 2.6301 (Cubit – 45.0586)

= 166.4571 + 4.0301 (Foot – 25.6877)

= 166.4572 – 0.6703 (Finger III – 11.5474) + 2.7886 (Cubit – 45.0586)

= 166.4572 + 2.8360 (Finger III – 11.5474) + 3.0304 (Foot - 25.6877)

Depuertuis and Hadden's formulae for stature from long bones [6, 19]

Male (cm)	Female (cm)
2.238 F + 69.089	2.317F + 61.412
2.392T + 81.688	2.533T + 72.572
2.970H + 73.570	3.144H + 64.977
3.650R + 80.405	3.876R + 73.502
1.255 (F + T) + 69.294	1.233 (F + T) + 65.213
1.728 (H + R) + 71.429	1.984 (H + R) + 55.729
1.422F + 1.062 T + 66.544	1.657F + 0.879T + 59.259
1.789 H + 1.841R + 66.400	2.164H + 1.525R + 60.344
1.928F + 0.568H + 64.505	2.009F + 0.566H + 57.600
1.422F + 0.931T + 0.083H + 0.480R + 56.006	1.544F + 0.764T + 0.126H + 0.295R + 57.495

The most useful and widely followed Trotter and Glesser equations modified in 1977 from original 1952 table by Krogman and Iscan (1986) are given below:[6]

White males	SE	Black males	SE
3.08 H + 70.45	4.05	3.26 H + 62.10	4.43
3.78 R + 79.01	4.32	3.42 R + 81.56	4.30
3.70 U + 74.05	4.32	3.26 U + 79.29	4.42
2.38 F + 61.41	3.27	2.11 F + 70.35	3.94
2.52 T + 78.62	3.37	2.19 T + 86.02	3.78
2.68 F + 71.78	3.29	2.19 F + 85.65	4.08
1.30 (F + T) + 63.29	2.99	1.15 (F + T) + 71.04	3.53
1.42 F + 1.24 T + 59.88	2.99	0.66 F + 1.62 T + 76.13	3.49
0.93 H + 1.94 T + 69.30	3.26	0.90 H + 1.78 T + 71.29	3.49
0.27 H +1.32 F +1.16 T + 58.57	2.99	0.89 H+1.01 R+0.38 F+1.92 T+ 74.56	3.38
White females	SE	Black females	SE
3.36 H + 57.97	4.45	3.08 H + 64.67	4.25
4.74 R+ 54.93	4.24	3.67 R + 71.79	4.59
4.27 U + 57.76	4.30	3.31 U + 75.38	4.83
2.47 F + 54.10	3.72	2.28 F+ 59.76	3.41
2.90 T + 61.53	3.66	2.45 T + 72.65	3.70
2.93 F + 59.61	3.57	2.49 F + 70.90	3.80
1.39 (F + T) + 53.20	3.55	1.26 (Fr + T) + 59.72	3.28
1.48 F + 1.28 T + 53.07	3.55	1.53 F + 0.96 T + 58.54	3.23
1.35 H+ 1.95 T + 52.77	3.67	1.08 H+ 1.79 T	3.58
0.68 H+1.17 F + 1.15 T + 50.12	3.51	0.44 H+ 20 R + 1.46 F+ 0.86 T + 56.33	3.22

All lengths are in centimeters valid only for Americans between 18 and 30 years of age, Femur and Tibia are maximum lengths.

With adult limbs bones plus vertebrae[28]

In **1960 Fully** and **Pineau** of France introduced an important variation of the prevailing mathematical method of stature estimation. They took into consideration the fact that the combined lengths of the femur and Tibia represent less than half of the combined lengths of all the skeletal parts contributing to stature and that of all the other parts the longest and most variable is the vertebral column.

Next, Fully and Pineau examined the correlation between stature and a combination of representative parts from the trunk and lower extremities. The combinations most favored were (I) femur length with length (height) of the five lumbar vertebrae (correlation with stature is 0.926), and (2) Tibia length with length (height) of the five lumbar vertebrae (correlation with stature is 0.908). For these two combinations they developed the following regression equations for use in estimating male stature.

$$1.09(\text{Femur} + 5 \text{ lumbars}) + 12.67 \pm 2.35 \text{ cm}$$

$$2.32 (\text{Tibia} + 5 \text{ lumbars}) + 48.63 \pm 2.54 \text{ cm}$$

Considering their low standard errors, these equations may prove to yield more reliable stature estimates for some European populations than any of the Trotter and Gleser equations.

With partial adult limb bones

Gertrude Muller of Vienna focused her attention to the bones fragments Tibia, humerus and radius. She divided them into readily defined segments and calculated the percentage of whole bone length represented by each.

More recently **(1970) Gentry Steele** used the least squares method of regression correlation with bones fragments, replacing the radius with the femur. Applying the various bone segments Steele produced series of equation involving various combinations.

With subadult limb bones

In Finland **Telkka et al. (1962)** studied rapidly growing children stature with their subadult limb bones, by measuring on radiographs the diaphyseal lengths of the long limb bones of 3848 children under fifteen years of age.

Oliver (1969) constructed a prediction table for estimating sub-adult stature from length of the femoral diaphysis. Yet another study by Oliver and Pineau (1958) cited by Oliver provide regression equations for estimating fetal stature from bone length.[29]

Fetal stature (cm) = 7.92 H – 0.32 ±1.80

= 13.80 R - 2.85±1.80

= 8.73 U – 1.07 ± 1.59

= 6.29 F + 4.42 ± 1.82

= 7.85 F + 2.78 ± 1.65

= 7.39 T + 3.55 ± 1.92

Fetal bones [5, 23, 24]

From measurements of the stature of 50 newly born children and the subsequent measurements of the dried bones without articular cartilages (i.e. diaphyses only) the following ratios have been calculated.

Stature of child	= Femur	X 6.71
Stature of child	= Tibia	X 7.63
Stature of child	= Humerus	X 7.60
Stature of child	= Radius	X 9.20
Stature of child	= Clavicle	X 11.30
Stature of child	= Lower Jaw (symphysis to condylar surface)	X 10.00

Anatomical method as practiced by Thomos Dwight[28]

Thomos Dwight (1894) developed anatomical method to estimate more accurate stature than any of the mathematical methods developed upto that time. Yet he seems not to have given much thought to the practical complication, time and expertise involved in using anatomical method as the results dependent to a great extent on skeletal completeness. Dwight's method comprises nine steps for the execution of which a stout laboratory table, long enough, for laying out a supine skeleton is required, besides good amount of modeling clay to support the individual bones in proper articulation. The various steps involved in stature estimation are as follows.

1. Making due allowance at the top end of the table for the eventual addition of the skull (step 8), embed the atlas and each succeeding vertebra down to the sacrum in a bed of clay with careful attention to the articulation of the posterior facets and thereby the reconstructions of the original curves.

2. Add the pelvis, articulating the posterior sacral facets with those of L5 in the same way as for the other vertebrae and taking care that the anterior superior spines of the ilia are on the same horizontal plane as the spines of the pubes.

3. Place the head of one of the femora in its acetabulum, making sure that the femoral head does not touch the rim of the acetabulum and that the plane of the inferior surfaces of both condyles is at a right angle to the long axis of the table.

4. Add the Tibia, leaving a space of 6 mm between it and the femur.

5. Add the talus, leaving a space of 3 mm between it and the T.

6. Add the calcaneus, leaving a space of 3 mm between it and the talus.

7. Allow 12 mm for the soft parts of the sole of the foot.

8. Add the skull to the atlas, leaving a space of 3 mm between their condyles.

9. Allow 6 mm for the thickness of the scalp.

The sum of the allowances for cartilage and external tissues in the foregoing procedure amounts to 32 mm. This figure seems to have satisfied

Thomos Dwight because of its closeness to the figure recommended by Topinard – 35 mm to be added to skeletal length for the soft parts.

As Practiced by Fully[28]

Fully's interest in using the vertebral column in connection with the estimation of stature has already been mentioned. In 1956 when Fully described his anatomical method in print he called it a "new method", because he was not aware of Dwights effort along this line made previously.

The essence of Fully's simplifications are (1) putting together of the bone measurements instead of the bones themselves, and (2) the substitution of a single correction factor for all the spaces between the bones plus scalp and sole thicknesses. The measurements utilized are as follow:

Skull: Basion – bregma height taken with spreading caliper.

C2 to L5 inclusive: Maximum height of the corpus of each taken with spreading caliper. The height of the dens is included in the height of C2 and thus takes care of the height of the atlas.

S1: Anterior height taken with sliding caliper.

Femur: Oblique length taken on standard osteometric board.

Tibia: Length without spine taken on Broca's osterometric board.

Talus and calcaneus articulated: Distance between the superior part of the tibiotalar articular surface and the most inferior part of the bearing surface of the calcaneus taken on standard osteometric board.

For skeletal statures of 153.5 cm or less add 10.0 cm

For skeletal statures of 153.6 – 165.4 cm add 10.5 cm

For skeletal statures of 165.5 cm or more add 11.5 cm

An example of stature calculation by Fully's anatomical method

Basion-bregma height	-	14.0 cm
Combined height C2-L5	-	51.7 cm
Height of S1	-	3.0 cm
Length of femur	-	46.5 cm
Length of Tibia	-	36.6 cm
Talocalcaneal height	-	6.0 cm

Total skeletal height	-	157.8 cm
Correction	-	+10.5 cm

Estimated stature		168.3 cm

Fully's anatomical method based on European skeletons. For other populations it needs to be tested for any correction factors.

All the formulae so for mentioned were formulated on the basis of statistical works on subjects of racial origin different from Indians. These are suitable for the people on whom and for whom these were worked out. As such these cannot be satisfactorily used for Indian subjects. Further, people of different corners of Indian bear different morphological features depending on their geographical distribution and primary racial attachment. For this reason a single formula cannot suit all parts of the country. The different formulae available for different parts of India are given below.[3]

These formulae are simpler to work out in the sense that a bone is to be multiplied by a factor to get the stature of the person. To mention some such formulae which are in use in our country.

1. Pan's formulae (1929) for males and females of Bihar, Bengal and Orissa;

2. Nat's formulae (1931) for male subjects of Uttar Pradesh and

3. Siddiqui and Shah's formulae (1944) for the males of Punjab and neighboring areas.[3]

Multiplication factors for different bones for calculation of stature of persons of different parts of India, based on the works of Pan (1924), Nat (1931) and Siddiqui and Shah (1944).[3]

Bones	Multiplication factors to get the stature			
	For Bengal, Bihar and Orissa – Pan (1924)		For U.P Nat (1931)	For Punjab Siddiqui & Shah (1944)
	Male	Female	Male	Male
Femur	3.82	3.8	3.7	3.6
Tibia	4.49	4.46	4.48	4.2
Fibula	4.46	4.43	4.48	4.4
Humerus	5.31	5.31	5.3	5.0
Radius	6.78	6.7	6.9	6.3
Ulna	6.0	6.0	6.3	6.0

Multiplication factors for hand and foot dimensions among different living population groups of India[10]

Population / Sex / Region	Multiplication factor		Author
	Hand length	Foot length	
A. North India			
1. Himachal Pradesh			
Rajput (M)	9.07	6.57	Kaur, 1996
Rajpur (F)	9.12	6.17	Kaur, 1996

2. Delhi			
Hindu Baniya (F)	9.11	6.64	Nath and Krishan, 1990
Punjabi (F)	9.12	6.67	Nath et al. 1990
Sikh (F)	9.18	-	Kaur and Nath,1997
Jats (F)	8.66	6.59	Jain et al., 1998
Sikh (M)	9.05	6.60	Kaur, 1998
Sikh (F)	9.24	6.79	Kaur, 1998
Bengali Sudras (F)	9.14	6.67	Nath et al., 1988
Bengali Brahmins (F)	9.19	6.68	Nath et al., 1998
Punjabi (F)	8.99	6.79	Sethi, 1998
Jain (F)	9.07	6.83	Sethi, 1998
Jain (M)	9.04	6.62	Jain, 1999
Jain (F)	9.12	6.75	Jain 1999
Bengali Badiyas (F)	9.21	6.79	Nath et al., 1999
Bengali Kayasthas (F)	9.16	6.68	Nath et al., 1999
Yadavs (M)	8.62	6.63	Nath et al., 1999
3. Uttranchal			
Brahmin (M) – Ranikhet	9.15	7.43	Tiwary, 1986
Raiput (M) – Ranikhet	9.14	7.46	Tiwary,1986
Rajput (M) – Dehradun	9.16	6.66	Garg, 1987
Raiput (F) – Dehradun	9.10	7.28	Garg, 1987
Brahmin (M), Garhwal	9.81	6.18	Anand, 1990
Brahmin (F) – Garhwal	9.08	6.79	Anand, 1990
Rajput (M) – Garhwal	9.08	6.42	Anand and Nath, 1990
Rajput (F)- Garhwal	9.39	7.13	Anand and Nath, 1990
Rajputs(M)–,Garhwal	9.25	6.87	Nath et al., 1987
Rajputs (F) –, Garhwal	9.37	6.73	Nath et al., 1998
Brahmins (M) –Garhwal	9.36	6.64	Nath et al., 1998
Brahmins (F) –, Garhwal	9.33	6.68	Nath et al., 1998
4. Rajasthan			
Jat (M) Churu	9.04	6.60	Nath, 1997
Jat (F) Churu	9.10	6.68	Nath, 1997
B. West India			
1.Maharashtra			
Warli (M)	9.06	6.49	Jain et al., 1999
C. East India			
1.Manipur			
Mongoloid Type (M+F)	9.00	-	Momonchand, 1992
Meiteis (M)	9.12	6.80	Devi Sunita, 2001
Meiteis (F)	9.09	6.88	Devi Sunita, 2001
2.West Bengal			
Lodha (M)	9.05	6.45	Duggal and Nath, 1986
Lodha (F)	9.13	6.22	Duggal and Nath, 1986
Munda (M)	8.65	6.24	Duggal and Nath, 1986
Munda (F)	8.94	6.26	Duggal and Nath, 1986
Lodha (M)	8.89	-	Kapoor, 1987

Journal references on stature estimation [2, 31-39]

Various Indian level and international level studies on stature estimation from dimensions of hands and feet [2, 31,32], cephalo – facial dimensions [33,34,35], vertebral column[36], bones of forearm [37], fragments of tibia[38], and calcaneus[39] showed positive conclusions and open the way for further regional level researches.

Medico-legal and general importance of stature

1. Stature is one of the three primary characteristics of identification(the other two characters are age and sex) Stature is one of the **great four** of forensic anthropology (the other three characters are race, sex and age)
2. Generally adult males are taller than females.
3. To a certain extent assessment of race is possible by stature. Americans, Africans, Europeans are usually taller. Chinese, Japanese, Mongolians are usually shorter.
4. It is an important tool in assessing the fetal age.
5. To a certain extent, it is used to assess children's age till puberty.
6. It is an important parameter along with weight in children's growth monitoring.
7. Adults can be classified by stature according to Martin and Schmitz table given before.
8. Adult's ideal weight calculation mainly based on stature[40].
    a. Stature is important for calculating Body Mass Index (Quetelet's index). BMI= Weight in kg. / square of height in meter. The normal range is between 20 and 25

b. Ponderal Index = Height in cm. / cubic weight of body weight in kg.

c. Broca Index = Height in cm. - 100 = Ideal weight in kg for adults.

d. According to one rule

(Height in cm. X Chest circumference in cm.) / 240, gives ideal weight in kg for adults.

9.

a. Some medical conditions with short stature as follows.

Dwarfism, Chronic malnutrition, Down's syndrome, Turner's syndrome, Hypopituitarism, Hypothyroidism

b. Some medical conditions with tall stature as follows.

Acromegaly, Gigantism, Klienfelter's syndrome, Marfan's syndrome, XXY male.

10. Stature is one of the important criteria in all personal profiles like, Bio-data, passport, identity card etc.,
11. In missing person complaint, stature is an important criterion.
12. During their first pregnancy females less than 140 cm. are considered as short statured primi-gravida – A high risk pregnancy.
13. In public road transport, persons above 130 cm. are charged full fare.
14. In postmortem examination, it is important to note the height and weight of the body.[21] for identification purpose.
15. Stature is an important requirement for the recruitment into Police service and Defense services.

Materials and methods

SECTION – IV

MATERIALS AND METHODS

The present study was conducted in the Institute of Forensic Medicine, Madras Medical College and also in the Institute of Internal Medicine, Government General Hospital, Chennai-600 003 in the year of 2007 over a period of 9 months from January to September.

The study sample consists of 619 Healthy individuals comprising 311 males and 308 females in the age group of 18 to 59 years. In this study the samples included are:

i) The medical students of second MBBS attached to the Institute of Forensic Medicine, Madras Medical College, Chennai.

ii) Apparently healthy individuals attending the outpatient department of general medicine and their accompanying attenders.

iii) Patients admitted in the medical wards having no abnormality in the hand and foot and spine and their accompanying attenders.

iv) General healthy population.

The size of sample was decided after consultation with the statistician who advised to involve minimum of 300 subjects in each sex to get good results. Hence 311 male and 308 female subjects were selected for the study.

The age range was decided between 18 and 59 years since most of the individuals attain their maximum stature and maximum hand and foot length by

18 years. This is because all the centers of ossification in the foot, hand and long bones get completely fused by 18 years.

Cases above 60 years were excluded since stature, hand length and foot length significantly decreases due to osteoporotic changes in the bones and various factors which affect old age individuals.

The study sample consists of mostly right handed preponderance however some cases of left hand dominance are also included. All the measurements were taken in well lighted room. Due care was taken while taking measurements to avoid any diurnal variation. In this study all the recording were made in the morning hours between 8 a.m. to 11 a.m.

Before taking measurements every subject was asked to remove his foot wear and head wear. The measurements were always taken by one observer and recorded by another person in order to avoid inter observer error. The measurements were taken using standard anthropometric instruments in cm. to the nearest mm accuracy according to the technique given in manual biological anthropology.[10]

The subjects included in the study were healthy and free from any apparent symptomatic deformity. Some general information pertaining to Name, Age, Sex, Address, Religion, Educational Status, Economic Status, Occupational status etc. were also obtained.

The sample was selected by applying the below mentioned inclusion and exclusion criteria.

Inclusion Criteria:

Willing healthy adult individuals of both sexes from Madras Medical College and Government General Hospital, Chennai between 18 to 59 years of age.

Exclusion Criteria:

1. Subjects less than 18 years
2. Subjects more than 59 years
3. Subjects with spinal deformities
4. Subjects with injuries to hand
5. Subjects with injuries to foot
6. Subjects with any major systemic diseases
7. Subjects with endocrine disorders
8. Pregnant women and lactating mothers
9. Unwilling individuals

Before venturing into the study, Ethical clearance was obtained from the Ethical committee headed by the Chairman (Dean, MMC). Prior permissions were obtained from the heads of the respective institutes for recording measurements from the subjects.

Before taking measurements each subject was explained about the procedure by which measurements were going to be taken, after getting fully informed written consent in the regional language which the subject can

understand well. Each subject's standing height, Right hand length, Left hand length, Right foot length and Left foot length were measured using standard anthropometric instruments by applying standard techniques. The data collected were subjected to statistical analysis by using SPSS (Statistical product and service solution) statistical software and regression formulas were derived with various combinations to reach the best estimate possible.

Landmarks and techniques involved in taking anthropometric measurements[10]

Stature:

It can be measured in two ways, one in standing position i.e. height-Vertex and the other in lying position i.e. horizontal body length.

1. Height-vertex or Standing height:

It is vertical distance between the point vertex and the floor when the subject stands in anatomical position with palms touching the thighs with head in Frankfurt horizontal plane

Anatomical position: The anatomical position of a man is erect posture with feet parallel to each other and arms hanging by the sides with palms facing forward.

Vertex: It is highest point on the head when head is held in Frankfurt Horizontal plane i.e. the lower border of orbit and the corresponding upper border of the ear canal in horizontal line parallel with the floor. This is not an anatomically determined point and is dependent on the orientation of the head.

2. Horizontal body length or Supine length:

It measures the projective distance between vertex and plantare on vertical axis.

Plantare: It is the lowest point on the sole. It normally lies on the lateral side.

Supine length usually measured in babies, dead bodies, in living subjects in emergency situation. This measurement is taken by laying the subject on a table. The subject should lie with his back in horizontal position on the table with his soles touching a vertical wall. The head should be in such a position that eye-ear plane is at right angle to the surface of the table. Supine length usually greater than standing height by 1.5cm – 2cm. It is not desirable to take measurement in the lying position unless there is urgent need. Measurements are usually taken in standing position all over the world.

Out of the two methods of taking height of a person, the standing height method was chosen for taking stature of a person, because it is most accepted method worldwide.

Instrument:

The instrument used for measuring stature estimation was obtained ready made from the market which consists of a horizontal squared flat wooden platform(18” X 18” X 3”) in which a vertical calibrated wooden rod is inserted and fixed at the middle part of the one among the four sides. The scale has got calibration from 0 – 195 cm. to the nearest mm accuracy. A flat projected horizontal sliding wooden bar, which can be moved from above

downwards, perpendicular to the vertical calibrated wooden rod is used to note the vertex point.

Technique:

The subject is made to stand in an erect posture and measurement is taken without any wear on head and foot. The subject should stand up on the platform against the vertical calibrated wooden rod, feet axis parallel or slightly divergent with head balanced on neck in F.H. plane. Hands should hang down. The movement of projected horizontal sliding wooden bar is controlled by the right hand, and moved from above downwards along mid saggital plane of the subject to just touch the vertex point. No pressure should be exerted since this is a contact measurement. Then it is fixed by the given screw at that level. The subject is then asked to step down and measurement noted in cm to the nearest mm accuracy.

Hand length:

There are four various methods by which the hand length can be measured like;

1. **Length of hand:** It measures the straight distance between the points interstylion and dactylion III.

   Interstylion: It is the mid point of the line joining the two stylia (i.e. the tip of the radial styloid process and the tip of the ulnar styloid process) projected on the dorsal surface of the hand. Schultz had taken this point on the volar side.

Dactylion III: It is the distal most point of the third finger (i.e. the tip of the middle finger) of the hand

2. **Projective hand length:** It is the vertical projective distance between stylion and dactylion, when the subject stands with arms and hands hanging down along the side of the body.

   Stylion: It is the deepest point on the styloid process of radius while the arm hanging by the side of the subject.

   Dactylion: It is the lowest point on the anterior margin of the middle finger with the arm hanging on the side of the subject.

3. **Total hand length:** It is straight distance from dactylion and mid-point of the most distal flexing crease of the wrist, while the hand is extended along the long axis of the forearm.

4. **Approximate hand length**: It is straight distance between stylion and dactylion.

   Note: Dactylion generally denotes tip of the middle finger and stylion generally denotes tip of the radial styloid process. **Dactylion-II** means the tip of the second finger. **Stylion ulnare** means the tip of the ulnare styloid process.

In this study, the total hand length method is applied to take hand length measurement to get more accurate results.

Instrument:

A specially designed instrument (depth gauge- 12” size) used commonly for measuring the depth of the holes is used for taking hand length measurements. It consist of a metal caliber which has measurements from 0 - 30 cm. with nearest mm accuracy. A movable metallic piece, which has flat surface at right angle to the caliber, attached with fixation screw and it can be moved along the long axis of the scale by releasing the fixation screw. It is used to touch the dactylion gently.

Technique:

The subject is asked to sit on a stool and to extend his hand with all the fingers together in correspondence with long axis of the forearm, on a table with dactylion protruding away from the edge of the table. The observer stands along the subject, place the instrument on the surface of the palm with the free end (zero point – 0.0cm) of the instrument fixed on the mid-point of the most distal flexing crease of wrist and the movable metallic piece is slided to touch the tip of the middle finger. Then it is fixed by tightening the fixation screw and it is taken out of the hand. Reading is noted. The same technique is applied for measuring both sides.

Foot length:

There are two methods by which the foot length can be measured like

1. **Length of foot:** It measures the straight distance directly from pternion to acropodian. The weight of the body should rest mainly on the foot being measured. The medial border of the foot should be placed parallel to the measuring instrument.

Acropodion: It is the most distally placed point on the toe-cap of the first or second toe when the foot is stretched. Acropodian lies on the first or second toe depending upon which one is longer.

Pternion: It is the hind-most point on the heel of the stretched foot.

2. **Projective foot length:** It is the projective distance between pternion and acropodian in the longitudinal axis of the foot i.e. along the line of second toe.

   This measurement is taken when the subject is standing and putting his weight in both a feet equally. The shaft of the measuring instrument must be placed parallel to the foot axis. This measurement can also be taken in a “foot box” designed by Hertzberg et al (1961). This measurement may be taken in sitting or standing position.

In this study, the first method was applied to take foot length measurement.

Instrument:

It is a specially designed instrument more or less like an osteometric board of a miniature size. It consists of a horizontal rectangular wooden platform with a fixed metal scale with calibration from 0 – 30 cm. to the nearest mm accuracy. A small wooden piece is permanently fixed perpendicular to the wooden platform at the zero point (0.0cm) of the scale. A movable wooden sleeve with its measuring borders at right angle to the calibrated platform, which can be moved along the horizontal plane of the platform parallel to the

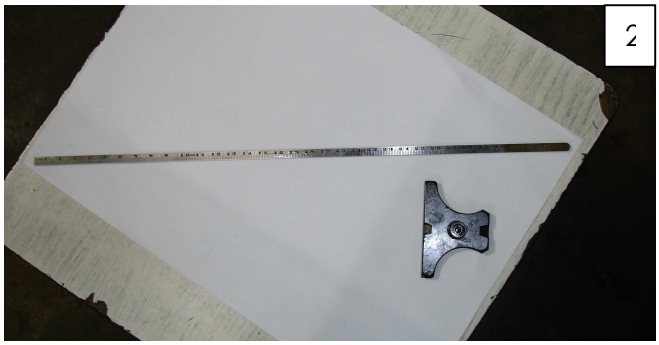
permanently fixed wooden piece from the other hand. It is used to touch the acropodian gently.

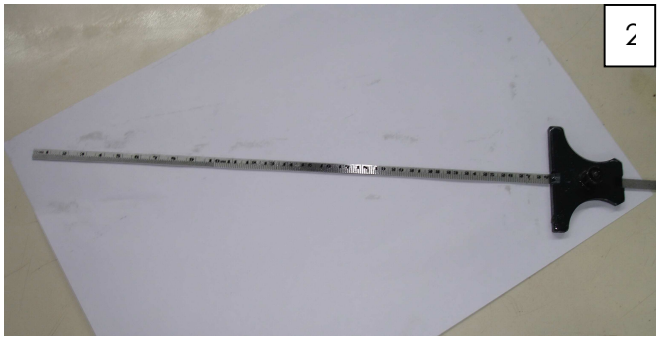
Technique:

The measurement recorded by allowing the subject to stand with one leg being slightly bend and drawn backwards so that the body rest mainly on the other foot which is to be measured. While taking measurement on right side, left foot is drawn backwards and bends and the right foot is placed over the rectangular wooden platform. The foot is held stretched with all the toes close together, with its medial border along and parallel to the one of the long borders of the rectangular platform. The pternion of the foot is allowed to gently touch the fixed wooden piece at the zero point (0.0cm) and the sliding wooden sleeve is allowed touch the acropodion. The recorder then fixes sliding sleeve with his right hand and the subject is asked to slowly take out the foot from the platform without any disturbance. The reading is then recorded from the scale. The same technique is applied for taking measurement for other foot.

While taking hand and foot measurement, the nails were clipped and trimmed if they were protruding beyond the points of acropodion and dactylion.

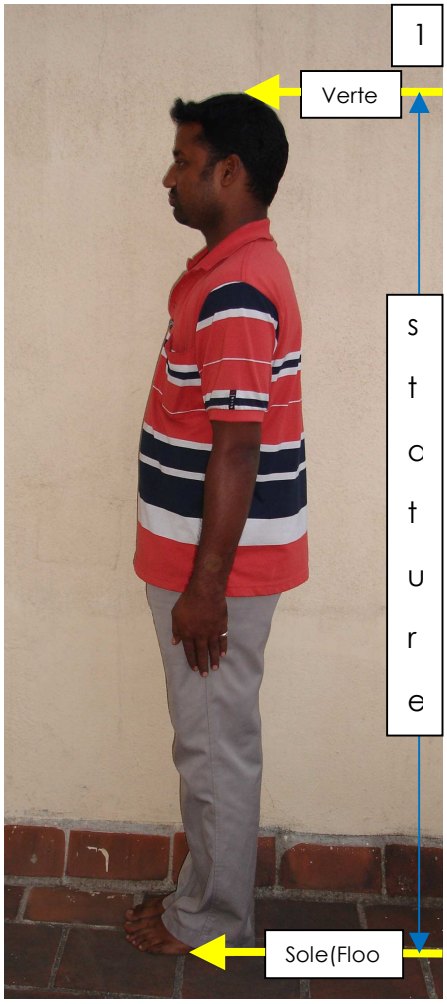
MATERIALS

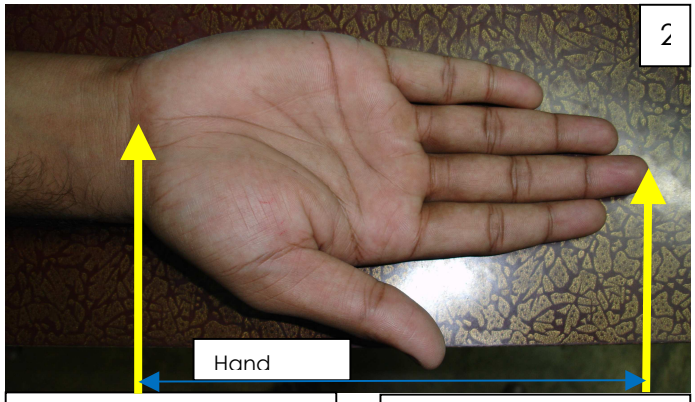




1. **Instrument for measuring standing height (stature).**
2. **Instrument for measuring hand length.**
3. **Instrument for measuring foot length.**

SOMATOMETRIC LANDMARKS





Mid point of most distal flexing wrist

Dactylion III: Tip of middle

Acropodion: Tip of most protruding

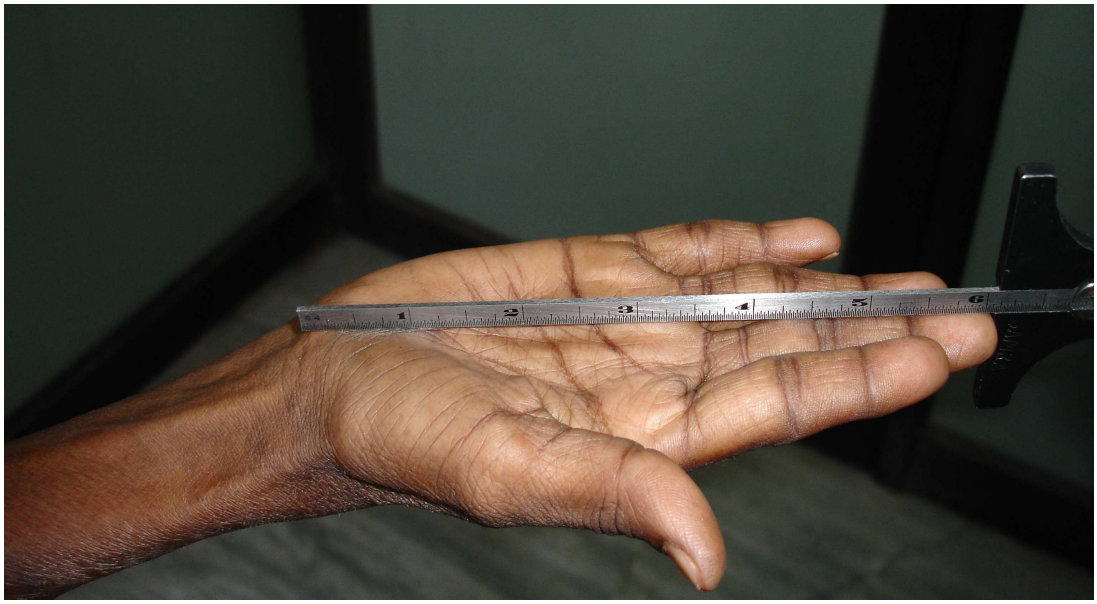
Pternion: Hind most point of

1. **Land marks for measuring standing height (stature)**
2. **Landmarks for measuring hand length**
3. **Landmarks for measuring foot length**

METHODOLOGY OF TAKING STATURE

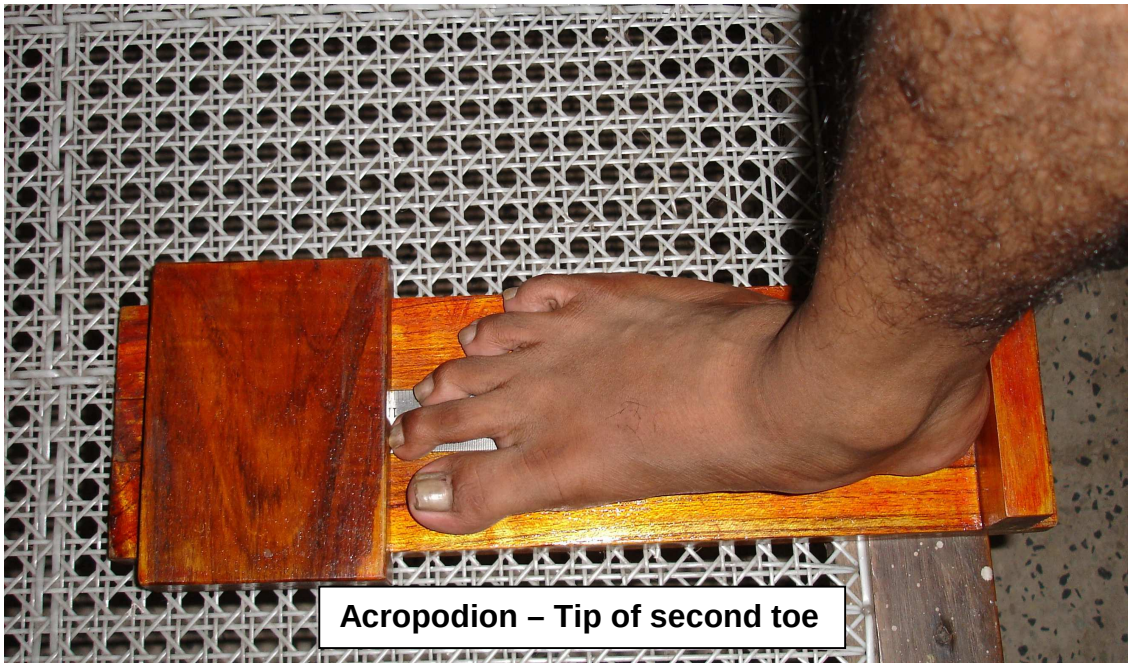
Technique of recording standing height measurement.

METHODOLOGY OF TAKING HAND LENGTH



Technique of recording Hand length measurement.

METHODOLOGY OF TAKING FOOT LENGTH



Technique of recording foot length measurement

Results and discussion

SECTION - V

RESULTS AND DISCUSSION

Table 1: Master Chart

Sl. No.	Sex	Age in years	Religion	Educational Qualification	Occupation	Stature (height) in cm	RHL in cm.	LHL in cm.	RFL in cm.	LFL in cm.
1	M	31	Hindu	Under Graduate	Govt. Employee	172.5	19.4	19.1	26.0	26.1
2	M	47	Hindu	S.S.L.C.	Govt. Employee	163.2	17.5	17.6	24.1	24.5
3	M	32	Christian	Post Graduate	Student	178.0	19.7	19.7	25.7	26.5
4	M	21	Hindu	Under Graduate	Student	169.1	18.9	19.2	26.0	25.6
5	M	21	Hindu	Under Graduate	Skilled Worker	165.6	17.9	18.4	25.1	25.0
6	M	19	Hindu	Under Graduate	Student	156.5	18.3	18.7	24.4	24.0
7	M	56	Hindu	S.S.L.C.	Office Assistant	164.0	18.3	18.3	25.3	24.8
8	M	34	Hindu	Post Graduate	Doctor	167.4	18.7	18.8	25.9	25.5
9	M	35	Hindu	Under Graduate	Doctor	168.5	18.6	18.6	26.5	26.8
10	M	26	Hindu	Under Graduate	Student	174.5	20.0	20.0	26.1	26.1
11	M	35	Hindu	Primary School	Unskilled Worker	157.0	17.3	17.5	23.1	22.8
12	M	48	Hindu	High School	Business	164.6	18.3	18.8	24.2	24.6
13	F	30	Hindu	Primary School	Unskilled Worker	161.8	17.6	17.7	24.2	24.0
14	M	28	Hindu	High School	Business	159.8	18.6	18.6	25.0	25.0
15	M	28	Hindu	Post Graduate	Doctor	173.0	19.2	19.0	26.2	26.6
16	M	26	Hindu	Post Graduate	Doctor	165.0	19.2	19.0	25.4	25.9
17	M	26	Hindu	Post Graduate	Doctor	171.2	19.7	19.3	26.7	26.6
18	M	26	Christian	Post Graduate	Doctor	162.8	18.3	18.6	24.6	24.9
19	M	42	Christian	Under Graduate	Skilled Worker	167.8	18.9	19.2	26.1	26.1
20	M	36	Hindu	Post Graduate	Doctor	172.4	19.3	19.3	27.2	27.2
21	M	23	Christian	Under Graduate	Student	182.0	19.5	19.5	25.8	25.4
22	M	29	Hindu	Post Graduate	Doctor	172.2	20.5	20.9	28.0	27.3
23	M	26	Hindu	Post Graduate	Doctor	172.0	20.5	20.6	28.1	28.1
24	M	27	Hindu	Post Graduate	Doctor	171.2	19.6	20.1	26.1	26.1
25	M	21	Muslim	Under Graduate	Student	170.0	18.8	19.0	25.7	25.1
26	M	26	Hindu	Post Graduate	Student	169.1	17.7	17.9	24.3	24.4
27	M	50	Hindu	Primary School	Business	172.0	19.0	19.0	26.2	26.2
28	M	45	Hindu	S.S.L.C.	Business	168.0	19.5	19.5	26.4	26.4
29	M	43	Hindu	S.S.L.C.	Govt. Employee	172.5	19.6	19.9	27.4	27.4
30	F	50	Hindu	Primary School	Home Maker	153.0	16.6	16.5	23.1	23.2
31	M	55	Hindu	Primary School	Office Assistant	164.0	18.1	18.2	25.5	25.8
32	M	20	Hindu	S.S.L.C.	Business	168.0	18.3	18.6	24.6	24.7
33	M	46	Christian	S.S.L.C.	Office Assistant	162.0	18.5	18.4	25.0	25.2
34	M	45	Hindu	High School	Business	158.5	17.3	17.1	23.1	24.0
35	M	22	Muslim	High School	Unskilled Worker	159.5	17.6	17.6	23.7	23.8
36	M	59	Muslim	S.S.L.C.	Business	164.3	17.9	18.0	24.9	25.0
37	M	29	Christian	Primary School	Unskilled Worker	152.8	17.1	17.0	24.3	24.5
38	M	33	Hindu	Under Graduate	Office Assistant	166.2	18.6	18.4	24.6	24.7
39	M	23	Hindu	High School	Unskilled Worker	160.6	18.5	18.2	23.8	23.7
40	F	24	Hindu	S.S.L.C.	Unskilled Worker	147.2	16.3	16.2	22.0	22.0
41	F	19	Hindu	Under Graduate	Student	157.3	17.5	17.4	23.2	23.1
42	F	55	Hindu	Primary School	Home Maker	155.1	18.2	18.0	24.4	24.0

43	F	31	Hindu	Primary School	Home Maker	157.0	17.8	17.7	23.8	24.5
44	F	25	Hindu	S.S.L.C.	Home Maker	149.4	15.9	16.0	22.2	22.3
45	F	32	Christian	High School	Home Maker	147.2	16.4	16.3	21.3	21.3
46	F	32	Hindu	High School	Home Maker	144.0	15.8	15.9	22.3	23.0
47	F	55	Hindu	Primary School	Home Maker	145.0	16.2	16.3	22.2	22.4
48	F	24	Hindu	High School	Home Maker	154.0	17.3	17.6	22.7	22.9
49	M	27	Hindu	Under Graduate	Teacher	171.0	17.3	17.3	24.3	24.5
50	F	30	Hindu	High School	Unskilled Worker	146.0	15.5	15.5	21.2	21.1
51	F	45	Hindu	Primary School	Home Maker	157.1	17.5	17.4	24.3	24.4
52	F	50	Hindu	Primary School	Home Maker	152.7	15.8	16.0	22.7	22.3
53	M	50	Hindu	Post Graduate	Doctor	181.0	20.3	20.4	27.5	27.6
54	M	21	Hindu	Under Graduate	Student	168.1	18.6	19.2	24.9	25.1
55	M	21	Hindu	Under Graduate	Student	166.9	18.7	18.8	26.2	26.2
56	M	20	Hindu	Under Graduate	Student	163.5	18.1	18.3	23.8	24.0
57	M	20	Hindu	Under Graduate	Student	170.3	19.4	20.0	26.4	26.3
58	M	21	Hindu	Under Graduate	Student	161.5	18.3	18.3	22.8	23.6
59	F	20	Hindu	Under Graduate	Student	155.3	17.6	17.5	24.8	24.8
60	F	20	Hindu	Under Graduate	Student	161.9	17.6	17.6	25.1	25.1
61	M	20	Hindu	Under Graduate	Student	170.3	18.4	18.9	25.8	25.8
62	M	21	Hindu	Under Graduate	Student	165.6	18.5	18.7	24.1	24.5
63	M	22	Hindu	Under Graduate	Student	171.0	19.0	19.1	25.3	25.1
64	F	22	Hindu	Under Graduate	Student	159.0	18.6	18.4	26.1	26.1
65	F	21	Hindu	Under Graduate	Student	155.8	17.5	17.8	23.0	23.2
66	F	20	Hindu	Under Graduate	Student	159.0	17.8	17.8	23.9	24.1
67	M	21	Hindu	Under Graduate	Student	172.0	19.0	19.3	25.2	25.5
68	M	21	Hindu	Under Graduate	Student	174.3	20.0	20.1	26.0	26.0
69	M	20	Hindu	Under Graduate	Student	165.0	18.2	18.4	24.6	24.1
70	M	19	Hindu	Under Graduate	Student	175.3	19.6	19.7	26.4	26.8
71	M	21	Hindu	Under Graduate	Student	182.0	19.7	20.4	27.7	27.9
72	M	21	Hindu	Under Graduate	Student	174.5	18.9	19.0	25.8	25.5
73	F	21	Hindu	Under Graduate	Student	159.0	16.6	16.9	23.0	22.6
74	M	20	Hindu	Under Graduate	Student	172.0	19.9	20.2	27.2	27.3
75	M	20	Hindu	Under Graduate	Student	176.2	19.7	19.8	27.1	27.3
76	M	19	Hindu	Under Graduate	Student	172.0	19.4	19.2	25.9	26.1
77	M	21	Hindu	Under Graduate	Student	171.2	18.7	18.9	25.8	25.9
78	F	19	Hindu	Under Graduate	Student	152.2	16.7	16.8	21.9	21.7
79	M	20	Hindu	Under Graduate	Student	172.0	18.1	18.2	25.2	25.2
80	F	20	Hindu	Under Graduate	Student	155.0	17.2	17.1	22.4	22.5
81	M	22	Hindu	Under Graduate	Student	172.9	19.0	19.3	25.6	26.0
82	F	20	Hindu	Under Graduate	Student	165.2	18.6	18.2	26.3	25.9
83	M	19	Hindu	Under Graduate	Student	171.0	18.5	18.6	23.8	24.3
84	F	19	Hindu	Under Graduate	Student	158.0	18.0	18.0	23.8	24.0
85	F	20	Hindu	Under Graduate	Student	152.0	17.1	17.1	22.9	22.9
86	M	21	Hindu	Under Graduate	Student	169.5	19.0	19.1	25.6	25.5
87	M	21	Hindu	Under Graduate	Student	168.0	19.1	19.4	25.9	25.9
88	M	38	Muslim	Post Graduate	Doctor	166.0	19.2	19.8	24.8	25.0
89	M	26	Hindu	Under Graduate	Student	168.0	17.8	18.2	24.5	25.1
90	M	26	Hindu	Under Graduate	Student	168.6	19.5	19.3	26.0	26.3
91	F	20	Hindu	Under Graduate	Student	151.0	16.6	16.6	23.1	23.0
92	M	21	Hindu	Under Graduate	Student	166.0	18.4	18.8	25.6	25.6
93	M	22	Hindu	Under Graduate	Student	163.8	19.5	18.9	25.3	25.2

94	M	22	Hindu	Under Graduate	Student	159.8	18.2	18.8	25.5	25.3
95	M	23	Hindu	Under Graduate	Student	174.8	19.0	18.9	27.0	27.0
96	M	21	Hindu	Under Graduate	Student	175.2	19.7	19.9	26.5	26.8
97	M	20	Muslim	Under Graduate	Student	171.0	18.7	19.2	25.6	25.8
98	F	21	Hindu	Under Graduate	Student	150.2	17.0	17.1	23.1	23.1
99	M	20	Hindu	Under Graduate	Student	172.8	19.0	19.3	26.7	26.9
100	M	22	Hindu	Under Graduate	Student	170.0	18.6	18.7	27.0	26.7
101	M	23	Hindu	H.S.C.	Business	166.6	18.6	18.8	25.3	24.8
102	M	21	Christian	Under Graduate	Student	176.6	19.9	19.7	27.3	26.9
103	M	20	Hindu	Under Graduate	Student	168.1	18.2	18.4	25.6	25.1
104	M	20	Hindu	Under Graduate	Student	165.1	17.9	18.6	25.2	25.5
105	F	20	Hindu	Under Graduate	Student	155.3	17.6	17.9	23.6	23.7
106	M	19	Hindu	Under Graduate	Student	180.0	20.3	20.1	27.9	27.8
107	M	20	Christian	Under Graduate	Student	174.0	19.0	18.5	24.3	24.9
108	M	20	Hindu	Under Graduate	Student	161.7	18.4	18.4	24.6	24.8
109	M	20	Hindu	Under Graduate	Student	165.1	17.4	17.4	23.6	23.8
110	M	20	Hindu	Under Graduate	Student	164.4	18.2	18.8	25.2	25.4
111	F	19	Hindu	H.S.C.	Dependent	170.0	18.3	18.5	24.7	24.5
112	M	22	Muslim	Under Graduate	Student	163.6	17.5	17.8	23.3	23.5
113	M	20	Hindu	Under Graduate	Student	172.1	18.9	19.2	25.7	25.6
114	M	19	Christian	Under Graduate	Student	146.1	16.2	16.7	21.3	21.8
115	F	19	Hindu	Under Graduate	Student	162.3	17.3	17.3	24.2	24.3
116	M	19	Hindu	Under Graduate	Student	190.0	21.4	21.5	29.0	29.2
117	M	19	Hindu	Under Graduate	Student	171.9	19.0	19.0	25.3	25.3
118	M	20	Hindu	Under Graduate	Student	175.5	19.3	19.5	26.2	26.9
119	F	20	Hindu	Under Graduate	Student	150.4	16.6	16.5	22.6	22.7
120	M	25	Hindu	Under Graduate	Student	159.2	17.8	18.1	23.8	23.7
121	M	24	Hindu	Under Graduate	Student	171.9	19.4	19.5	25.6	26.2
122	M	26	Hindu	Post Graduate	Engineer	167.0	18.4	18.6	25.9	25.5
123	F	20	Christian	Under Graduate	Student	162.6	17.4	17.7	22.9	23.1
124	F	20	Muslim	Under Graduate	Student	153.9	17.8	17.6	23.7	23.9
125	F	21	Hindu	Under Graduate	Student	162.2	18.1	18.5	25.8	25.5
126	F	20	Christian	Under Graduate	Student	164.6	17.1	17.2	22.7	23.5
127	F	20	Hindu	Under Graduate	Student	163.2	17.8	17.5	24.3	24.4
128	M	20	Christian	Under Graduate	Student	184.0	20.6	20.2	27.5	27.5
129	M	20	Hindu	Under Graduate	Student	173.7	19.5	19.7	25.6	26.1
130	F	20	Hindu	Under Graduate	Student	157.6	17.8	17.9	24.3	24.4
131	F	21	Hindu	Under Graduate	Student	159.4	16.9	16.9	24.2	24.7
132	F	21	Christian	Under Graduate	Student	149.2	16.3	16.5	21.6	21.5
133	M	21	Hindu	Under Graduate	Student	176.0	19.2	18.7	25.5	25.7
134	F	20	Hindu	Under Graduate	Student	166.7	19.4	19.0	25.1	25.3
135	F	21	Hindu	Under Graduate	Student	149.0	16.5	16.7	22.5	22.2
136	M	21	Hindu	Under Graduate	Student	169.4	19.5	19.5	26.5	26.7
137	M	21	Hindu	Under Graduate	Student	179.8	20.0	20.2	27.2	28.0
138	M	20	Hindu	Under Graduate	Student	175.3	19.8	20.2	26.1	26.9
139	F	19	Hindu	Under Graduate	Student	154.6	17.2	17.1	23.2	23.2
140	M	21	Hindu	Under Graduate	Student	169.9	17.9	18.2	24.2	24.3
141	M	21	Christian	Under Graduate	Student	165.4	19.3	18.8	26.2	26.1
142	M	21	Hindu	Under Graduate	Student	170.6	19.3	19.5	25.7	26.5
143	F	20	Hindu	S.S.L.C.	Home Maker	162.7	17.1	17.2	23.9	24.1
144	M	20	Hindu	Under Graduate	Student	183.0	19.8	19.8	27.5	27.7

145	F	20	Hindu	Under Graduate	Student	156.3	17.5	17.2	23.4	23.1
146	F	21	Hindu	Under Graduate	Student	164.9	18.7	18.9	25.7	25.5
147	F	20	Hindu	Under Graduate	Student	162.0	16.4	16.5	23.0	23.1
148	M	21	Hindu	Under Graduate	Student	169.2	18.6	18.6	24.8	25.1
149	F	20	Hindu	Under Graduate	Student	155.8	18.1	17.9	23.4	24.3
150	M	20	Hindu	Under Graduate	Student	164.4	18.6	18.3	23.4	23.7
151	M	20	Hindu	Under Graduate	Student	174.6	19.3	19.0	26.7	26.6
152	M	20	Christian	Under Graduate	Student	172.4	19.1	19.3	25.1	25.2
153	M	21	Hindu	Under Graduate	Student	171.8	20.1	20.1	26.8	26.9
154	M	21	Hindu	Under Graduate	Student	174.1	19.7	19.5	25.7	26.1
155	M	20	Hindu	Under Graduate	Student	176.2	19.4	19.3	25.8	26.4
156	F	19	Hindu	Under Graduate	Student	153.9	17.0	17.0	23.5	23.6
157	F	21	Hindu	Under Graduate	Student	157.6	17.1	17.0	23.7	23.5
158	F	20	Hindu	Under Graduate	Student	154.7	16.2	16.1	22.7	22.8
159	F	20	Hindu	Under Graduate	Student	151.3	17.0	17.1	22.7	22.9
160	F	20	Hindu	Under Graduate	Student	151.9	17.0	17.2	22.4	22.5
161	F	21	Hindu	Under Graduate	Student	160.3	17.7	17.7	23.4	24.4
162	M	19	Hindu	Under Graduate	Student	180.8	19.3	19.7	26.4	26.9
163	M	51	Hindu	Post Graduate	Teacher	173.8	17.4	17.8	23.6	24.3
164	M	23	Hindu	Under Graduate	Student	175.4	18.8	18.9	25.7	26.3
165	F	24	Hindu	Under Graduate	Student	153.1	17.1	17.5	21.9	21.5
166	M	24	Hindu	Under Graduate	Student	178.2	19.5	19.9	26.4	26.3
167	M	48	Hindu	S.S.L.C.	Govt. Employee	168.7	18.8	19.2	26.7	26.8
168	F	46	Hindu	Primary School	Office Assistant	144.8	16.7	16.7	21.2	21.3
169	F	57	Christian	Under Graduate	Nurse	153.9	17.1	17.3	22.7	22.7
170	M	22	Hindu	Under Graduate	Student	175.2	20.7	20.9	26.8	27.0
171	M	22	Hindu	Under Graduate	Student	167.3	18.7	18.7	25.6	25.5
172	M	23	Muslim	Under Graduate	Student	171.5	19.6	19.6	25.3	25.7
173	M	22	Hindu	Under Graduate	Student	169.3	18.6	18.5	25.9	26.0
174	M	22	Hindu	Under Graduate	Student	165.6	19.0	18.9	24.9	25.2
175	M	47	Hindu	Under Graduate	Govt. Employee	168.0	20.6	20.6	25.6	26.2
176	M	21	Hindu	Under Graduate	Student	185.5	20.8	20.6	28.6	29.2
177	M	24	Hindu	Under Graduate	Student	172.1	19.0	19.1	25.7	25.9
178	F	23	Christian	Under Graduate	Student	167.5	18.1	18.2	24.1	24.2
179	F	22	Hindu	Under Graduate	Student	156.8	17.1	17.3	24.0	23.7
180	M	24	Hindu	Under Graduate	Student	173.3	19.0	19.0	24.9	24.7
181	M	22	Hindu	Under Graduate	Student	166.2	18.0	18.2	24.3	25.0
182	F	36	Hindu	Post Graduate	Doctor	156.2	16.3	16.6	22.3	22.2
183	F	30	Christian	Post Graduate	Doctor	154.8	17.4	17.2	23.5	22.8
184	F	31	Hindu	Post Graduate	Doctor	156.6	16.7	16.9	23.6	24.0
185	M	29	Hindu	Post Graduate	Doctor	171.3	18.7	18.7	25.3	25.3
186	M	33	Hindu	Post Graduate	Doctor	167.7	18.3	18.9	25.2	24.7
187	F	28	Hindu	Post Graduate	Doctor	160.1	18.2	18.1	23.4	23.6
188	F	23	Christian	Under Graduate	Student	162.7	16.9	16.8	22.5	22.4
189	F	23	Christian	Under Graduate	Student	158.6	18.3	18.3	23.8	24.0
190	F	24	Hindu	Under Graduate	Doctor	173.8	18.0	18.0	23.8	23.3
191	F	22	Hindu	Under Graduate	Doctor	157.5	16.5	16.3	22.3	22.6
192	F	23	Hindu	Under Graduate	Doctor	153.8	16.9	17.0	22.3	22.5
193	M	31	Hindu	Under Graduate	Doctor	164.5	18.5	18.6	25.3	25.8
194	M	34	Hindu	Post Graduate	Doctor	166.8	19.2	19.0	25.7	25.6
195	M	26	Hindu	Primary School	Unskilled Worker	159.3	17.7	18.2	24.1	23.3

196	M	42	Hindu	H.S.C.	Govt. Employee	170.8	18.5	18.8	25.3	25.7
197	M	47	Hindu	H.S.C.	Govt. Employee	170.4	19.0	19.4	26.3	26.6
198	M	38	Hindu	Post Graduate	Doctor	163.8	18.2	18.5	24.4	24.4
199	M	22	Hindu	Under Graduate	Student	171.2	18.5	18.6	25.0	24.5
200	M	22	Hindu	Under Graduate	Student	161.3	17.5	17.5	24.4	24.3
201	M	23	Muslim	Under Graduate	Student	173.0	18.5	18.6	24.5	24.6
202	M	23	Hindu	Under Graduate	Student	177.8	19.8	19.6	27.4	26.7
203	M	22	Hindu	Under Graduate	Student	173.2	18.4	19.2	26.5	25.9
204	F	30	Hindu	High School	Home Maker	156.2	18.4	18.4	23.3	23.6
205	F	23	Hindu	H.S.C.	Skilled Worker	159.2	18.5	18.4	23.5	23.5
206	F	41	Hindu	S.S.L.C.	Home Maker	157.2	18.7	18.7	24.2	24.3
207	F	28	Hindu	High School	Home Maker	156.3	17.4	18.2	23.5	23.4
208	F	21	Hindu	High School	Home Maker	151.1	16.8	16.8	22.7	22.5
209	F	55	Hindu	Illiterate	Home Maker	154.1	17.9	17.5	23.8	23.6
210	F	49	Hindu	Illiterate	Home Maker	153.3	18.1	18.0	23.7	24.0
211	F	24	Hindu	Primary School	Unskilled Worker	152.6	16.8	17.3	22.5	22.3
212	F	48	Hindu	Illiterate	Unskilled Worker	157.8	18.6	18.8	23.0	22.8
213	F	23	Hindu	Primary School	Unskilled Worker	152.6	17.0	17.0	22.7	22.4
214	F	35	Hindu	Primary School	Home Maker	152.0	16.7	16.4	22.6	23.0
215	F	40	Hindu	Under Graduate	Teacher	153.7	17.1	16.9	22.4	21.9
216	F	37	Hindu	Primary School	Unskilled Worker	156.0	17.4	17.9	23.9	24.1
217	F	45	Hindu	High School	Home Maker	145.9	16.3	16.4	22.0	21.8
218	F	42	Hindu	Illiterate	Unskilled Worker	150.3	17.4	17.7	22.6	22.9
219	F	45	Hindu	S.S.L.C.	Home Maker	151.9	16.5	16.7	22.7	22.8
220	F	19	Hindu	S.S.L.C.	Home Maker	161.5	18.1	18.1	24.5	24.6
221	F	32	Christian	High School	Home Maker	161.3	18.1	18.1	24.5	24.1
222	F	22	Hindu	Under Graduate	Student	159.8	17.2	17.3	23.4	22.6
223	F	23	Hindu	Under Graduate	Student	149.0	16.3	16.1	22.1	21.7
224	F	23	Hindu	Under Graduate	Student	159.5	18.1	18.0	23.0	23.2
225	F	22	Hindu	Under Graduate	Student	162.8	18.5	18.6	24.0	24.3
226	F	23	Hindu	Under Graduate	Student	161.8	17.7	17.4	23.8	23.5
227	F	18	Hindu	S.S.L.C.	Student	150.0	16.6	17.2	22.4	22.4
228	F	24	Hindu	High School	Home Maker	147.0	16.2	16.0	20.3	21.2
229	F	30	Hindu	S.S.L.C.	Home Maker	142.5	16.1	16.3	21.2	21.7
230	F	35	Hindu	Primary School	Home Maker	147.5	16.5	16.7	21.6	22.5
231	F	45	Hindu	Primary School	Home Maker	153.8	17.1	17.4	23.1	22.7
232	F	50	Christian	Primary School	Home Maker	161.2	17.7	18.3	24.2	24.3
233	F	40	Hindu	Primary School	Unskilled Worker	150.2	17.0	17.0	22.4	22.7
234	F	57	Hindu	Illiterate	Unskilled Worker	150.6	18.0	18.0	24.5	25.1
235	F	57	Hindu	High School	Home Maker	150.1	17.1	17.2	23.1	23.1
236	F	30	Christian	S.S.L.C.	Home Maker	164.7	18.3	18.5	24.3	24.5
237	F	55	Hindu	Primary School	Home Maker	147.2	17.4	17.2	22.2	22.1
238	F	37	Hindu	Primary School	Home Maker	144.2	16.1	16.2	22.0	22.1
239	F	40	Hindu	Illiterate	Home Maker	154.9	18.4	18.4	24.2	23.9
240	F	32	Hindu	High School	Home Maker	152.3	16.3	16.1	22.7	22.8
241	F	19	Hindu	High School	Unskilled Worker	150.8	16.1	15.9	21.8	22.0
242	F	43	Hindu	Primary School	Unskilled Worker	145.2	16.0	16.2	22.0	22.7
243	F	25	Hindu	High School	Home Maker	156.8	17.7	17.6	22.7	22.8
244	F	30	Hindu	Primary School	Home Maker	142.2	16.2	16.1	19.9	20.1
245	F	32	Hindu	Primary School	Home Maker	144.2	17.6	17.7	22.0	22.8
246	F	37	Hindu	H.S.C.	Home Maker	150.3	17.5	17.4	21.8	22.2

247	F	35	Hindu	Primary School	Home Maker	152.5	17.2	17.2	23.3	23.1
248	F	29	Hindu	S.S.L.C.	Home Maker	154.2	17.4	17.3	23.9	23.7
249	F	35	Hindu	Primary School	Home Maker	157.2	17.2	17.6	23.1	22.5
250	F	20	Hindu	S.S.L.C.	Dependent	150.6	16.0	16.1	21.7	21.8
251	F	45	Hindu	Primary School	Home Maker	150.8	17.2	17.4	23.7	23.5
252	F	36	Hindu	Primary School	Home Maker	148.8	16.9	17.4	23.2	22.7
253	F	37	Muslim	Primary School	Home Maker	140.2	16.6	16.5	22.1	22.3
254	F	30	Hindu	Primary School	Home Maker	147.1	16.6	16.7	20.9	20.9
255	F	38	Hindu	High School	Home Maker	151.3	16.4	16.0	21.9	22.3
256	F	35	Hindu	High School	Skilled Worker	154.9	17.2	16.7	22.0	22.0
257	F	40	Hindu	Primary School	Home Maker	156.5	18.4	18.2	24.5	24.2
258	F	32	Hindu	Primary School	Unskilled Worker	154.6	17.4	17.4	22.9	22.5
259	F	39	Hindu	High School	Home Maker	147.1	17.2	17.0	22.2	22.2
260	F	33	Hindu	S.S.L.C.	Skilled Worker	146.0	15.1	15.0	20.7	20.0
261	F	35	Hindu	Illiterate	Unskilled Worker	149.4	16.9	17.2	23.1	23.4
262	F	34	Christian	Under Graduate	Teacher	158.0	16.9	17.0	22.8	23.1
263	F	31	Hindu	H.S.C.	Home Maker	152.8	17.7	17.9	22.3	22.4
264	F	50	Hindu	High School	Home Maker	145.0	17.5	17.2	23.4	23.4
265	F	27	Christian	High School	Home Maker	163.5	18.5	18.3	25.1	25.5
266	F	37	Hindu	S.S.L.C.	Skilled Worker	159.8	17.5	17.5	22.5	22.7
267	F	30	Christian	Under Graduate	Home Maker	164.2	17.8	17.5	24.1	24.8
268	F	40	Hindu	Primary School	Unskilled Worker	156.6	17.5	17.5	24.0	24.5
269	F	18	Hindu	Primary School	Skilled Worker	160.5	18.2	18.0	24.0	24.0
270	F	58	Hindu	Primary School	Unskilled Worker	146.2	17.1	17.6	24.3	24.2
271	F	38	Muslim	S.S.L.C.	Home Maker	166.2	18.8	18.6	23.9	23.7
272	F	35	Hindu	S.S.L.C.	Home Maker	151.5	17.2	17.2	22.2	21.5
273	F	30	Hindu	High School	Home Maker	148.1	16.1	16.5	22.3	22.2
274	F	32	Muslim	Post Graduate	Home Maker	157.5	16.6	17.0	21.7	22.1
275	F	28	Hindu	High School	Skilled Worker	152.2	16.4	16.8	23.4	23.2
276	F	52	Hindu	Primary School	Home Maker	148.1	17.1	17.2	23.0	22.9
277	F	18	Christian	H.S.C.	Student	153.4	17.4	17.5	22.5	22.4
278	F	41	Christian	Primary School	Home Maker	154.0	17.2	17.0	22.7	22.4
279	F	34	Hindu	S.S.L.C.	Home Maker	156.8	16.2	16.5	21.9	22.1
280	F	33	Hindu	Primary School	Unskilled Worker	141.6	15.5	15.9	21.0	21.9
281	F	25	Hindu	High School	Home Maker	151.8	16.8	16.7	21.9	22.3
282	F	28	Hindu	Primary School	Home Maker	147.9	16.8	16.9	22.4	23.0
283	F	40	Hindu	Primary School	Unskilled Worker	149.2	18.0	18.0	24.6	24.5
284	F	24	Hindu	Under Graduate	Govt. Employee	161.7	17.2	17.3	22.3	22.0
285	F	28	Hindu	Under Graduate	Govt. Employee	162.2	18.6	18.5	24.9	24.7
286	F	27	Hindu	High School	Home Maker	146.4	15.9	15.7	21.2	21.3
287	F	28	Hindu	Primary School	Home Maker	159.2	17.2	17.0	24.1	24.6
288	F	55	Hindu	Primary School	Home Maker	139.8	16.3	16.1	22.0	22.1
289	F	30	Muslim	Primary School	Home Maker	157.1	16.7	16.8	23.1	22.5
290	F	35	Hindu	High School	Unskilled Worker	153.2	16.7	16.8	21.6	21.7
291	F	40	Hindu	High School	Home Maker	152.8	17.7	18.2	22.3	22.0
292	F	37	Hindu	Illiterate	Unskilled Worker	158.9	18.0	18.2	23.8	23.1
293	F	20	Hindu	H.S.C.	Dependent	155.6	17.3	17.0	22.5	22.3
294	F	45	Hindu	S.S.L.C.	Home Maker	152.3	16.7	16.7	21.6	21.7
295	F	29	Hindu	High School	Unskilled Worker	161.2	17.2	17.1	22.6	22.7
296	F	35	Hindu	Primary School	Unskilled Worker	149.3	17.2	17.7	23.1	22.9
297	F	34	Hindu	High School	Home Maker	147.2	16.4	16.9	22.6	22.6

298	F	35	Muslim	High School	Home Maker	155.5	17.7	17.8	23.0	23.1
299	F	29	Hindu	High School	Home Maker	163.5	18.3	18.2	24.7	24.5
300	F	50	Hindu	High School	Home Maker	164.3	18.9	19.0	25.6	24.9
301	F	32	Hindu	Primary School	Home Maker	156.9	16.6	16.9	23.2	23.2
302	F	35	Hindu	S.S.L.C.	Home Maker	142.6	15.7	15.7	20.3	20.3
303	F	38	Hindu	Primary School	Home Maker	149.2	17.8	18.0	23.4	23.2
304	F	24	Muslim	Primary School	Home Maker	142.9	15.8	15.5	20.7	20.7
305	F	35	Hindu	Primary School	Home Maker	153.1	17.7	17.7	23.3	23.6
306	F	44	Hindu	Primary School	Home Maker	143.2	17.1	16.9	22.9	23.0
307	F	30	Christian	Primary School	Home Maker	155.9	18.0	18.1	24.6	24.7
308	F	37	Hindu	S.S.L.C.	Home Maker	156.2	18.2	18.2	23.0	23.0
309	F	28	Hindu	Primary School	Home Maker	145.9	17.4	17.3	22.2	22.4
310	F	37	Hindu	Primary School	Unskilled Worker	151.6	17.1	17.3	24.2	24.0
311	F	40	Hindu	Primary School	Skilled Worker	154.6	17.9	18.1	23.3	22.9
312	F	40	Hindu	Primary School	Skilled Worker	152.6	18.2	18.4	23.6	23.7
313	F	35	Muslim	Primary School	Home Maker	158.2	18.9	18.9	26.1	26.4
314	F	26	Hindu	High School	Home Maker	161.2	18.4	18.0	24.3	24.2
315	F	30	Hindu	Under Graduate	Teacher	149.1	17.5	17.4	23.5	22.8
316	F	52	Hindu	H.S.C.	Home Maker	149.0	17.0	17.2	23.7	23.8
317	F	35	Hindu	Primary School	Home Maker	151.8	17.4	17.4	23.1	22.9
318	F	19	Hindu	Under Graduate	Student	149.6	17.1	17.0	23.1	22.9
319	F	39	Hindu	H.S.C.	Home Maker	155.3	17.7	17.8	22.7	22.9
320	F	32	Hindu	Primary School	Home Maker	147.1	16.5	16.3	21.0	21.1
321	F	59	Hindu	Primary School	Home Maker	158.0	17.6	17.9	23.5	23.5
322	F	18	Hindu	High School	Dependent	151.8	16.8	16.7	22.3	22.8
323	M	28	Hindu	Under Graduate	Student	171.7	18.1	18.0	25.1	25.2
324	F	28	Hindu	Under Graduate	Student	178.0	19.2	19.0	25.5	25.2
325	F	28	Hindu	Under Graduate	Student	155.3	16.8	17.2	23.4	22.8
326	F	30	Muslim	H.S.C.	Govt. Employee	158.6	17.2	17.1	22.8	23.0
327	M	47	Hindu	S.S.L.C.	Govt. Employee	170.5	19.5	20.0	27.3	27.2
328	F	20	Hindu	Under Graduate	Student	155.5	17.0	17.0	21.5	21.7
329	M	19	Hindu	Under Graduate	Student	183.0	20.2	20.3	26.2	26.2
330	F	20	Muslim	Under Graduate	Student	158.6	18.0	18.4	25.0	25.1
331	F	20	Hindu	Under Graduate	Student	165.1	18.1	18.0	24.2	23.4
332	F	19	Hindu	Under Graduate	Student	168.8	17.5	17.0	24.4	24.6
333	F	19	Hindu	Under Graduate	Student	152.0	17.4	17.6	23.4	23.4
334	M	20	Hindu	Under Graduate	Student	170.0	19.0	19.1	26.4	26.6
335	M	21	Hindu	Under Graduate	Student	155.0	16.9	17.2	22.8	23.4
336	M	20	Hindu	Under Graduate	Student	178.0	19.4	19.2	27.0	27.1
337	M	19	Hindu	Under Graduate	Student	170.6	18.6	18.8	25.5	25.3
338	F	20	Hindu	Under Graduate	Student	159.5	17.3	17.5	23.1	23.9
339	F	20	Hindu	Under Graduate	Student	153.8	16.8	16.8	23.0	22.5
340	F	19	Hindu	Under Graduate	Student	155.0	17.7	18.2	23.6	24.1
341	F	20	Hindu	Under Graduate	Student	159.8	17.6	17.4	23.1	23.2
342	F	20	Hindu	Under Graduate	Student	151.0	17.0	16.7	22.6	22.5
343	M	19	Hindu	Under Graduate	Student	165.2	19.5	19.9	26.3	26.2
344	M	20	Muslim	Under Graduate	Student	164.9	18.5	18.4	25.0	24.6
345	F	19	Hindu	Under Graduate	Student	165.1	17.9	18.1	24.7	24.1
346	F	20	Hindu	Under Graduate	Student	161.2	18.2	18.2	24.5	24.3
347	F	19	Hindu	Under Graduate	Student	156.2	17.1	16.8	22.6	22.3
348	F	20	Hindu	Under Graduate	Student	172.0	18.8	18.6	24.7	24.8

349	F	19	Hindu	Under Graduate	Student	160.5	16.6	16.5	23.1	22.9
350	M	20	Hindu	Under Graduate	Student	178.0	19.5	19.3	25.3	25.6
351	M	19	Christian	Under Graduate	Student	159.8	17.7	17.9	24.2	24.5
352	M	19	Hindu	Under Graduate	Student	173.2	19.1	19.3	26.6	25.9
353	M	20	Hindu	Under Graduate	Student	179.2	19.1	19.2	26.9	26.8
354	M	20	Hindu	Under Graduate	Student	172.0	19.9	19.7	26.9	26.9
355	F	20	Hindu	Under Graduate	Student	161.9	16.9	16.9	23.5	23.5
356	F	18	Hindu	Under Graduate	Student	165.7	18.1	17.8	24.8	25.2
357	F	20	Hindu	Under Graduate	Student	156.6	18.3	18.3	25.3	25.7
358	M	19	Hindu	Under Graduate	Student	165.9	19.3	19.9	26.2	25.6
359	M	22	Hindu	Under Graduate	Student	177.1	20.3	20.2	28.1	28.1
360	M	19	Hindu	Under Graduate	Student	155.8	17.3	17.3	24.2	23.9
361	M	22	Hindu	Under Graduate	Skilled Worker	166.8	19.3	19.4	26.0	25.8
362	M	57	Hindu	S.S.L.C.	Skilled Worker	161.9	19.7	19.5	25.3	25.3
363	F	41	Hindu	S.S.L.C.	Home Maker	155.1	17.0	17.1	23.2	23.1
364	F	19	Hindu	Under Graduate	Student	156.1	17.2	17.2	23.2	23.5
365	F	32	Hindu	Primary School	Home Maker	144.4	16.0	16.1	20.3	20.6
366	F	44	Christian	Primary School	Home Maker	153.1	17.4	17.2	23.4	23.0
367	F	23	Hindu	S.S.L.C.	Home Maker	159.5	18.1	18.3	24.8	24.6
368	F	28	Hindu	S.S.L.C.	Home Maker	141.0	15.5	15.8	21.8	21.8
369	F	19	Hindu	Primary School	Dependent	159.8	18.0	17.7	23.9	23.4
370	F	19	Hindu	High School	Dependent	150.1	17.2	17.2	22.8	22.9
371	M	33	Hindu	Under Graduate	Skilled Worker	157.8	18.6	18.9	25.0	25.2
372	F	32	Hindu	High School	Home Maker	155.6	17.3	17.3	23.1	23.4
373	F	30	Hindu	Primary School	Home Maker	150.1	17.1	17.1	22.6	22.9
374	M	20	Hindu	Under Graduate	Student	163.2	18.2	18.0	24.9	25.1
375	M	21	Hindu	Under Graduate	Student	172.6	19.1	19.2	25.5	25.4
376	F	34	Hindu	S.S.L.C.	Home Maker	144.6	16.3	16.8	23.0	22.8
377	F	40	Hindu	High School	Home Maker	148.1	17.0	16.9	23.0	22.9
378	M	33	Hindu	High School	Unskilled Worker	157.3	16.4	16.6	23.0	23.2
379	M	36	Hindu	Primary School	Unskilled Worker	153.9	17.0	17.1	23.1	23.7
380	F	20	Hindu	Under Graduate	Student	158.0	17.7	17.9	23.5	23.9
381	F	20	Hindu	Under Graduate	Student	155.9	17.0	16.7	22.6	23.1
382	M	20	Hindu	Under Graduate	Student	158.6	18.1	18.4	23.9	23.5
383	M	20	Hindu	Under Graduate	Student	168.0	18.2	18.1	24.6	24.4
384	M	19	Hindu	Under Graduate	Student	168.4	19.1	19.5	25.5	25.2
385	M	19	Hindu	Under Graduate	Student	166.8	19.2	19.7	25.9	26.0
386	M	20	Hindu	Under Graduate	Student	187.8	21.2	21.1	30.4	30.3
387	M	20	Muslim	Under Graduate	Student	166.0	17.6	17.8	23.9	24.3
388	F	24	Hindu	High School	Home Maker	156.0	17.1	17.6	23.2	23.6
389	F	37	Hindu	High School	Home Maker	153.1	17.8	17.6	23.3	23.1
390	F	49	Hindu	High School	Home Maker	151.4	16.7	16.8	24.0	23.7
391	F	19	Hindu	S.S.L.C.	Dependent	149.3	17.1	16.9	22.1	22.3
392	F	26	Hindu	High School	Home Maker	145.5	16.7	16.6	21.4	21.6
393	F	35	Hindu	High School	Home Maker	142.7	16.2	16.0	21.3	21.8
394	F	18	Hindu	S.S.L.C.	Dependent	150.7	17.1	17.0	22.3	22.3
395	F	25	Hindu	S.S.L.C.	Home Maker	151.2	17.8	17.9	23.4	23.5
396	M	38	Hindu	Primary School	Unskilled Worker	160.1	18.9	19.1	27.4	27.3
397	M	41	Hindu	High School	Unskilled Worker	171.0	18.9	18.7	25.8	26.0
398	F	30	Hindu	Under Graduate	Govt. Employee	160.8	18.5	18.7	24.7	24.6
399	F	37	Hindu	Post Graduate	Doctor	150.0	17.2	17.0	22.8	23.0

400	M	35	Hindu	Post Graduate	Doctor	157.0	18.0	17.7	24.9	24.8
401	F	21	Hindu	Under Graduate	Student	154.6	17.0	17.1	21.9	21.9
402	F	21	Hindu	Under Graduate	Student	161.0	17.7	17.7	24.5	24.2
403	F	21	Hindu	Under Graduate	Student	161.6	18.0	17.9	23.5	23.4
404	F	21	Hindu	Under Graduate	Student	158.2	18.1	18.0	24.1	24.3
405	M	21	Hindu	Under Graduate	Student	167.8	18.6	18.6	24.6	24.9
406	M	20	Hindu	Under Graduate	Student	174.1	19.8	19.9	26.8	26.7
407	M	21	Hindu	Under Graduate	Student	161.0	17.6	17.7	23.7	23.4
408	M	21	Hindu	Under Graduate	Student	175.1	19.3	19.6	26.0	26.4
409	M	20	Hindu	Under Graduate	Student	172.2	20.1	20.5	26.1	26.2
410	M	21	Hindu	Under Graduate	Student	165.2	18.4	18.0	24.1	24.6
411	M	32	Hindu	Post Graduate	Doctor	171.5	19.1	19.2	26.9	26.8
412	M	49	Hindu	S.S.L.C.	Govt. Employee	178.0	19.9	19.9	26.9	26.7
413	M	45	Hindu	S.S.L.C.	Govt. Employee	170.4	18.8	19.0	26.7	26.3
414	F	23	Hindu	Under Graduate	Student	154.4	17.2	17.1	23.3	23.3
415	F	22	Hindu	Under Graduate	Student	159.4	16.8	17.0	22.9	22.9
416	F	23	Hindu	Under Graduate	Student	161.7	18.0	18.2	24.0	23.1
417	F	22	Hindu	Under Graduate	Student	156.5	17.0	17.0	23.7	23.7
418	M	22	Christian	Under Graduate	Student	170.9	18.4	18.4	25.6	25.5
419	F	52	Hindu	Primary School	Unskilled Worker	139.6	16.5	17.1	22.3	22.7
420	F	39	Hindu	High School	Home Maker	152.0	16.1	16.6	22.0	22.3
421	F	45	Hindu	High School	Home Maker	155.6	16.5	16.8	23.3	23.2
422	F	30	Hindu	High School	Home Maker	152.5	17.3	17.5	22.5	22.4
423	M	53	Muslim	High School	Unskilled Worker	159.7	17.6	17.9	24.4	24.4
424	F	34	Hindu	High School	Business	151.0	16.6	16.4	21.6	21.5
425	F	40	Muslim	S.S.L.C.	Home Maker	143.6	16.1	15.9	21.6	21.8
426	F	28	Muslim	High School	Home Maker	143.5	15.9	16.0	20.6	20.7
427	M	23	Hindu	High School	Skilled Worker	170.9	19.3	20.0	26.1	26.3
428	F	37	Hindu	Primary School	Unskilled Worker	157.1	16.8	17.0	24.1	23.7
429	M	18	Hindu	Under Graduate	Student	167.6	18.0	18.3	24.2	24.5
430	M	47	Hindu	High School	Unskilled Worker	154.0	18.7	18.4	23.9	23.8
431	M	40	Hindu	S.S.L.C.	Skilled Worker	159.8	17.5	17.4	23.9	23.7
432	F	35	Hindu	Primary School	Unskilled Worker	154.3	17.3	17.3	22.2	22.4
433	F	39	Hindu	Primary School	Unskilled Worker	153.4	17.9	17.9	23.7	23.5
434	F	28	Hindu	High School	Home Maker	150.0	15.8	15.9	21.4	21.4
435	M	26	Hindu	Primary School	Unskilled Worker	172.1	18.9	19.0	25.6	25.4
436	F	36	Hindu	Primary School	Unskilled Worker	147.0	16.8	17.3	22.9	22.8
437	F	50	Hindu	Primary School	Home Maker	144.1	16.3	16.3	20.3	20.6
438	M	48	Hindu	Primary School	Unskilled Worker	158.7	17.5	17.8	23.9	24.0
439	F	32	Hindu	High School	Home Maker	146.5	17.0	16.9	22.5	22.4
440	F	18	Hindu	Primary School	Dependent	152.9	17.4	17.1	22.5	23.0
441	F	37	Hindu	Primary School	Home Maker	149.7	17.1	17.1	23.1	22.4
442	F	35	Hindu	High School	Home Maker	155.3	18.0	18.3	23.1	23.1
443	F	35	Hindu	Primary School	Home Maker	140.5	15.2	15.2	19.6	19.6
444	F	50	Hindu	Primary School	Unskilled Worker	154.0	18.1	18.0	23.9	24.0
445	F	25	Hindu	Primary School	Unskilled Worker	153.9	18.1	18.0	24.2	24.3
446	F	38	Hindu	Primary School	Home Maker	151.1	17.4	17.3	23.4	23.4
447	F	45	Hindu	Primary School	Home Maker	153.3	16.7	16.8	23.4	23.4
448	F	40	Christian	High School	Home Maker	154.5	18.7	18.2	24.9	24.3
449	F	20	Muslim	High School	Dependent	148.6	16.7	16.3	21.8	21.6
450	F	35	Hindu	Primary School	Home Maker	153.8	18.6	18.9	24.9	25.0

451	F	32	Hindu	High School	Home Maker	146.4	17.2	17.1	22.3	22.0
452	F	41	Hindu	High School	Home Maker	158.6	17.0	17.2	22.9	23.3
453	F	18	Hindu	Under Graduate	Student	164.4	18.0	18.0	23.6	23.6
454	F	35	Muslim	Primary School	Unskilled Worker	146.9	16.1	16.0	21.9	21.8
455	F	38	Hindu	High School	Home Maker	151.7	17.1	17.5	22.1	22.8
456	F	25	Hindu	S.S.L.C.	Home Maker	151.2	17.6	17.5	22.8	23.0
457	F	32	Hindu	Primary School	Home Maker	155.6	18.3	18.3	24.3	23.8
458	F	38	Hindu	High School	Home Maker	151.5	18.7	18.6	24.0	23.6
459	F	19	Hindu	Under Graduate	Student	158.5	17.3	17.6	23.2	23.5
460	F	32	Hindu	S.S.L.C.	Home Maker	153.9	17.3	17.0	23.3	23.4
461	F	46	Hindu	Primary School	Home Maker	161.6	18.7	18.8	25.8	25.8
462	M	35	Hindu	S.S.L.C.	Skilled Worker	165.0	18.7	18.7	25.5	25.6
463	F	40	Hindu	Primary School	Home Maker	144.2	17.2	17.0	23.1	23.2
464	F	39	Hindu	Primary School	Home Maker	151.1	17.0	17.2	23.3	22.8
465	F	27	Hindu	High School	Home Maker	153.6	17.1	17.0	21.6	22.1
466	F	38	Hindu	S.S.L.C.	Home Maker	144.2	16.7	16.9	21.1	20.8
467	F	30	Hindu	Primary School	Home Maker	151.8	17.1	17.5	22.6	22.8
468	F	28	Hindu	Primary School	Home Maker	156.2	17.1	17.2	23.9	24.7
469	F	24	Christian	High School	Home Maker	153.6	16.0	16.2	23.0	22.9
470	F	50	Hindu	Primary School	Home Maker	157.1	18.4	18.0	24.0	24.2
471	F	34	Hindu	Primary School	Home Maker	150.0	17.5	17.9	22.6	22.8
472	F	28	Hindu	High School	Home Maker	154.1	16.8	16.9	22.2	22.4
473	F	42	Hindu	Primary School	Home Maker	149.8	17.7	18.1	23.1	22.7
474	F	25	Hindu	Post Graduate	Home Maker	149.4	17.1	17.0	22.8	22.7
475	F	35	Hindu	Primary School	Home Maker	151.3	17.2	17.2	22.6	22.5
476	F	25	Christian	S.S.L.C.	Home Maker	146.1	16.5	16.4	22.3	22.1
477	F	47	Hindu	S.S.L.C.	Home Maker	144.6	16.5	16.4	22.1	22.1
478	F	55	Hindu	High School	Home Maker	149.4	16.4	16.5	21.3	21.8
479	F	26	Hindu	Under Graduate	Nurse	164.3	17.9	18.1	23.7	23.9
480	F	26	Hindu	Primary School	Home Maker	149.9	16.3	17.1	23.1	22.8
481	F	20	Hindu	S.S.L.C.	Dependent	157.5	17.8	17.9	23.1	23.6
482	F	30	Hindu	High School	Home Maker	151.5	17.7	17.9	23.7	23.9
483	M	52	Hindu	High School	Business	157.2	17.6	18.1	23.7	24.0
484	M	40	Hindu	Primary School	Skilled Worker	166.2	19.7	20.2	26.4	26.5
485	M	24	Hindu	High School	Skilled Worker	160.4	18.0	18.3	24.5	24.6
486	M	25	Hindu	H.S.C.	Skilled Worker	168.8	19.0	19.5	25.5	25.3
487	M	22	Hindu	Under Graduate	Student	173.4	20.1	20.6	26.9	26.9
488	M	22	Hindu	Under Graduate	Student	175.7	20.9	20.6	27.9	28.3
489	M	23	Hindu	Under Graduate	Student	167.0	19.8	20.3	26.0	26.5
490	M	21	Hindu	Under Graduate	Student	177.1	19.2	19.4	26.6	26.7
491	M	23	Hindu	Under Graduate	Student	156.0	16.6	16.9	23.8	23.6
492	F	24	Hindu	Under Graduate	Student	154.7	17.1	17.3	22.6	23.1
493	F	47	Hindu	High School	Home Maker	158.7	17.2	17.5	22.6	22.3
494	F	50	Hindu	Primary School	Home Maker	145.1	16.8	16.7	22.1	22.1
495	F	59	Hindu	Primary School	Home Maker	152.2	17.8	17.9	23.1	22.5
496	F	31	Hindu	Primary School	Home Maker	143.8	15.8	15.9	22.8	22.8
497	F	30	Hindu	S.S.L.C.	Home Maker	154.0	18.6	18.5	24.7	24.6
498	M	40	Hindu	High School	Business	167.0	18.2	18.5	24.9	25.4
499	M	29	Hindu	H.S.C.	Business	168.8	19.3	19.5	26.1	26.5
500	M	22	Hindu	High School	Business	167.8	19.9	19.9	25.1	25.1
501	M	32	Hindu	High School	Business	152.1	17.0	17.1	22.3	22.3

502	M	40	Hindu	Primary School	Unskilled Worker	179.4	20.8	20.7	27.6	27.8
503	M	36	Hindu	High School	Unskilled Worker	161.6	18.8	19.4	24.7	25.0
504	M	52	Hindu	High School	Business	153.3	17.7	17.9	23.5	23.8
505	M	24	Hindu	Under Graduate	Business	162.0	18.6	18.6	24.1	24.1
506	M	35	Hindu	High School	Skilled Worker	166.2	17.3	17.6	25.4	25.9
507	M	49	Hindu	H.S.C.	Unskilled Worker	161.0	17.3	17.5	23.8	23.9
508	M	56	Muslim	H.S.C.	Unskilled Worker	170.6	18.3	18.6	24.4	24.5
509	M	54	Hindu	Primary School	Unskilled Worker	161.9	18.0	18.0	23.8	24.2
510	M	55	Hindu	High School	Unskilled Worker	165.5	18.8	19.0	26.2	25.9
511	M	20	Hindu	S.S.L.C.	Skilled Worker	164.0	18.5	18.6	25.6	25.1
512	M	43	Muslim	High School	Unskilled Worker	152.1	18.1	18.2	23.4	23.2
513	M	45	Hindu	Primary School	Unskilled Worker	160.8	17.0	17.4	23.6	23.5
514	M	30	Hindu	Primary School	Unskilled Worker	148.0	16.4	16.5	22.6	22.6
515	F	18	Hindu	S.S.L.C.	Unskilled Worker	164.0	18.1	18.2	23.3	23.4
516	M	23	Hindu	H.S.C.	Unskilled Worker	171.0	17.0	17.0	24.4	24.3
517	M	44	Hindu	High School	Unskilled Worker	161.3	17.7	18.2	24.4	24.4
518	M	27	Hindu	High School	Skilled Worker	172.2	18.6	19.2	27.3	27.5
519	M	50	Hindu	Primary School	Business	161.9	18.5	18.6	25.9	25.4
520	M	37	Muslim	High School	Unskilled Worker	147.7	17.3	17.7	22.3	22.0
521	M	30	Hindu	Primary School	Unskilled Worker	166.2	19.0	19.4	26.7	26.3
522	M	53	Hindu	S.S.L.C.	Business	162.0	18.7	18.7	26.1	25.6
523	M	36	Hindu	S.S.L.C.	Unskilled Worker	167.8	18.5	18.6	23.2	23.5
524	M	57	Hindu	High School	Business	162.2	18.9	18.9	25.6	25.1
525	M	48	Christian	Primary School	Unskilled Worker	174.2	19.5	19.5	25.3	25.1
526	M	46	Hindu	Primary School	Unskilled Worker	165.9	18.5	18.9	25.8	25.5
527	M	41	Hindu	High School	Skilled Worker	154.3	17.4	17.7	24.1	23.8
528	M	40	Hindu	Primary School	Unskilled Worker	168.0	18.3	18.8	24.3	24.3
529	M	24	Hindu	H.S.C.	Unskilled Worker	171.8	18.2	18.4	24.3	24.0
530	M	40	Muslim	High School	Unskilled Worker	160.0	17.4	17.6	24.4	24.3
531	M	21	Hindu	Under Graduate	Student	167.7	18.5	18.2	23.8	23.8
532	M	20	Hindu	S.S.L.C.	Skilled Worker	175.2	18.9	19.1	25.3	25.5
533	M	35	Hindu	S.S.L.C.	Govt. Employee	164.0	18.2	18.7	24.8	25.0
534	M	23	Hindu	High School	Skilled Worker	161.1	18.4	18.4	23.3	23.2
535	M	35	Christian	S.S.L.C.	Unskilled Worker	153.1	16.9	17.0	21.9	22.4
536	M	45	Hindu	High School	Unskilled Worker	169.3	18.4	18.9	25.3	25.7
537	M	22	Hindu	Illiterate	Unskilled Worker	151.8	17.4	17.7	23.4	23.4
538	M	56	Hindu	High School	Business	169.5	20.2	20.3	25.2	25.8
539	M	52	Christian	High School	Unskilled Worker	163.2	19.0	19.1	24.6	25.2
540	M	20	Hindu	Under Graduate	Student	166.2	17.9	18.0	24.4	24.6
541	M	32	Hindu	Under Graduate	Skilled Worker	169.0	19.5	20.0	27.6	27.6
542	M	29	Hindu	H.S.C.	Unskilled Worker	155.2	17.2	17.0	23.2	23.6
543	M	20	Hindu	S.S.L.C.	Skilled Worker	164.3	17.9	18.0	24.2	24.2
544	M	55	Muslim	High School	Unskilled Worker	174.0	19.4	19.8	26.6	26.7
545	M	28	Hindu	High School	Skilled Worker	172.2	19.2	19.7	25.9	26.0
546	M	39	Hindu	Primary School	Unskilled Worker	161.3	17.9	18.1	24.0	24.3
547	M	39	Hindu	High School	Unskilled Worker	167.1	18.2	18.5	25.8	25.8
548	M	55	Hindu	Primary School	Office Assistant	162.5	18.0	18.4	23.8	23.6
549	M	23	Hindu	High School	Skilled Worker	161.5	19.4	19.2	25.9	26.4
550	M	21	Hindu	Under Graduate	Student	167.8	18.5	18.7	24.3	25.1
551	M	21	Hindu	Under Graduate	Student	171.0	18.2	18.9	23.9	24.3
552	M	21	Hindu	Under Graduate	Student	172.1	19.4	19.4	24.3	24.4

553	M	21	Hindu	Under Graduate	Student	175.1	19.3	19.7	26.5	26.1
554	M	21	Hindu	Under Graduate	Student	177.1	20.1	20.4	27.9	28.0
555	M	21	Hindu	S.S.L.C.	Business	169.0	18.7	18.7	24.0	23.6
556	M	30	Hindu	S.S.L.C.	Unskilled Worker	157.5	19.1	19.1	23.7	24.2
557	M	24	Hindu	High School	Skilled Worker	162.8	17.4	17.4	23.9	24.3
558	M	21	Hindu	Primary School	Unskilled Worker	165.0	18.9	19.0	24.2	24.3
559	M	37	Hindu	Primary School	Skilled Worker	166.5	18.2	18.4	25.7	25.6
560	M	30	Hindu	Primary School	Unskilled Worker	153.0	17.0	17.0	23.1	23.7
561	M	56	Hindu	S.S.L.C.	Govt. Employee	163.2	18.3	18.3	24.4	24.5
562	M	44	Hindu	Primary School	Skilled Worker	159.9	18.6	19.0	24.8	25.0
563	M	38	Hindu	Primary School	Skilled Worker	164.8	19.1	19.3	25.1	25.8
564	M	30	Hindu	S.S.L.C.	Skilled Worker	165.9	19.6	19.7	25.4	25.8
565	M	45	Hindu	High School	Unskilled Worker	162.5	19.0	19.2	25.3	25.3
566	M	32	Hindu	High School	Skilled Worker	162.0	17.6	18.1	24.1	24.2
567	M	42	Christian	S.S.L.C.	Office Assistant	162.7	19.6	19.6	25.4	25.9
568	M	45	Hindu	S.S.L.C.	Skilled Worker	157.6	17.9	18.2	24.1	24.2
569	M	32	Hindu	S.S.L.C.	Business	168.5	19.4	19.7	24.8	24.4
570	M	49	Hindu	Primary School	Skilled Worker	158.0	18.7	18.5	25.3	25.4
571	M	55	Hindu	Primary School	Unskilled Worker	161.9	18.1	18.2	23.1	23.6
572	M	35	Hindu	S.S.L.C.	Office Assistant	167.6	18.8	18.9	25.5	25.4
573	M	40	Hindu	High School	Unskilled Worker	156.6	18.2	18.3	23.6	24.3
574	M	20	Hindu	High School	Skilled Worker	164.1	19.7	19.2	25.8	26.2
575	M	32	Hindu	High School	Skilled Worker	162.2	19.2	19.1	25.6	25.9
576	M	48	Hindu	S.S.L.C.	Office Assistant	158.9	18.9	19.3	24.9	24.3
577	M	29	Hindu	High School	Skilled Worker	171.0	19.2	19.3	25.9	25.6
578	F	22	Hindu	Under Graduate	Student	152.0	16.6	16.5	24.3	24.2
579	F	23	Hindu	Under Graduate	Student	163.6	19.6	19.2	24.5	24.6
580	F	23	Hindu	Under Graduate	Student	149.1	16.8	17.0	22.4	21.7
581	M	22	Hindu	Under Graduate	Student	182.2	20.9	20.3	27.8	27.7
582	M	22	Hindu	Under Graduate	Student	181.9	19.6	19.9	26.6	26.2
583	M	30	Hindu	Under Graduate	Engineer	161.2	18.6	19.2	24.5	24.5
584	M	43	Hindu	H.S.C.	Skilled Worker	167.8	18.6	18.6	24.4	24.7
585	M	30	Hindu	Under Graduate	Office Assistant	166.0	19.5	19.5	24.9	25.4
586	M	28	Hindu	S.S.L.C.	Skilled Worker	161.2	18.6	18.8	25.6	25.7
587	M	43	Hindu	H.S.C.	Skilled Worker	170.8	19.4	19.6	26.8	26.8
588	M	57	Hindu	Primary School	Business	161.0	18.0	18.5	25.3	25.4
589	M	36	Hindu	High School	Skilled Worker	163.6	18.4	18.6	26.2	26.0
590	M	29	Hindu	H.S.C.	Business	165.7	19.0	19.1	24.1	24.0
591	M	54	Hindu	S.S.L.C.	Business	166.7	18.5	18.5	25.9	25.4
592	M	41	Hindu	Primary School	Business	152.9	17.6	18.4	24.8	24.6
593	M	29	Hindu	High School	Unskilled Worker	167.3	19.1	20.0	27.6	27.4
594	M	32	Hindu	High School	Office Assistant	167.6	18.5	18.4	23.9	24.2
595	M	20	Christian	Under Graduate	Skilled Worker	173.0	19.2	19.1	24.3	25.0
596	M	23	Hindu	H.S.C.	Business	153.1	18.1	18.1	23.4	24.0
597	M	35	Hindu	S.S.L.C.	Skilled Worker	163.0	18.3	18.5	25.5	25.5
598	M	20	Hindu	Under Graduate	Student	174.9	18.5	18.5	25.7	25.5
599	M	26	Hindu	S.S.L.C.	Skilled Worker	167.9	18.4	18.8	25.6	25.3
600	M	29	Hindu	S.S.L.C.	Unskilled Worker	175.6	19.5	20.5	26.0	26.6
601	F	23	Hindu	Under Graduate	Student	167.3	18.6	18.6	25.5	25.3
602	F	23	Hindu	Under Graduate	Student	160.9	17.6	17.7	23.8	23.4
603	F	23	Hindu	Under Graduate	Student	145.1	15.8	15.9	20.6	20.4

604	M	23	Hindu	Under Graduate	Student	156.0	17.6	17.8	24.0	24.3
605	M	51	Hindu	Primary School	Unskilled Worker	162.9	17.9	18.0	24.6	24.7
606	M	34	Hindu	Primary School	Unskilled Worker	158.2	17.7	17.5	23.6	23.7
607	M	22	Hindu	Under Graduate	Teacher	174.3	21.3	21.6	27.8	27.5
608	M	26	Hindu	Under Graduate	Skilled Worker	174.5	19.6	19.9	27.7	27.6
609	M	41	Hindu	H.S.C.	Unskilled Worker	163.4	18.8	18.8	25.9	26.0
610	M	30	Hindu	High School	Unskilled Worker	155.7	17.7	17.5	23.2	23.5
611	M	26	Hindu	High School	Skilled Worker	177.4	21.2	21.3	28.1	28.3
612	M	22	Hindu	S.S.L.C.	Skilled Worker	165.5	18.9	18.9	25.2	25.5
613	M	37	Muslim	Under Graduate	Office Assistant	166.6	18.0	18.1	25.3	24.9
614	M	54	Hindu	S.S.L.C.	Unskilled Worker	166.7	19.3	19.1	26.0	26.0
615	M	40	Muslim	Primary School	Skilled Worker	159.2	17.6	17.9	25.3	24.9
616	M	22	Hindu	S.S.L.C.	Skilled Worker	167.8	18.7	18.9	26.5	26.4
617	M	25	Hindu	Under Graduate	Office Assistant	173.2	20.4	20.2	25.8	25.6
618	M	32	Hindu	Post Graduate	Teacher	170.7	19.1	19.6	25.5	25.4
619	M	29	Hindu	H.S.C.	Skilled Worker	157.3	17.4	17.2	23.1	23.2

M-Male; F-Female; RHL - Right Hand Length; LHL-Left Hand Length; RFL-Right Foot Length; LFL- Left Foot Length

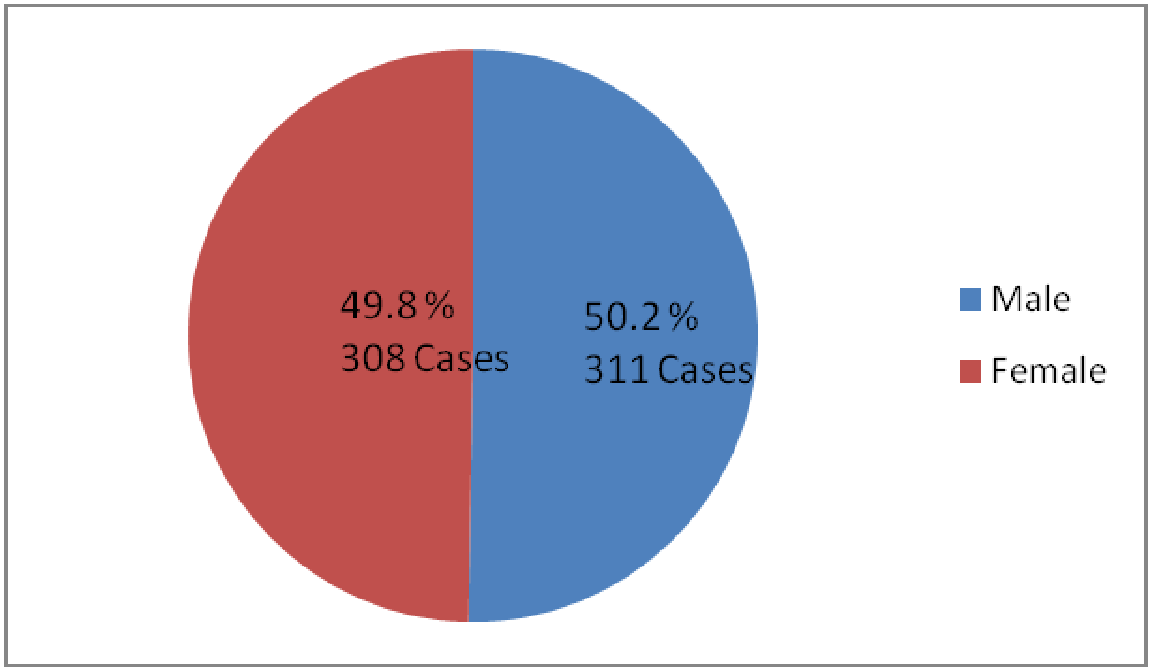
Table: 1 shows the master chart which is the compilation of all the data collected for this study from 619 subjects. It includes the details of selected variables and other demographic particulars.

In this study 619 cases were taken up for analysis of various parameters like hand length on both sides, foot length on both sides individually and collectively, ipsilateral and contralateral combinations of hand and foot length with the relevance to the stature of the individual.

Table: 2 Sex distribution among the study sample.

Sex	Frequency	Percentage
Male	311	50.2
Female	308	49.8
Total	619	100.0

Figure 1: Sex distribution among the study sample.



According to Table: 2 and figure: 1, the sex distribution among the total 619 cases is as follows. Males -311 cases, Female -308 cases. This constitutes 50.2% of males and 49.8% of females. Care has been taken to effectively make the sex distribution equally for both males and females.

Table: 3 Age wise distribution of the study sample

Age in years	Frequency	Percentage
18	10	1.6
19	39	6.3
20	85	13.7
21	57	9.2
22	35	5.7
23	33	5.3
24	19	3.1
25	11	1.8
26	18	2.9
27	6	1.0
28	19	3.1
29	13	2.1
30	28	4.5
31	6	1.0
32	24	3.9
33	6	1.0
34	9	1.5
35	30	4.8
36	8	1.3
37	15	2.4
38	11	1.8
39	7	1.1
40	21	3.4
41	8	1.3
42	5	0.8
43	5	0.8
44	4	0.6
45	15	2.4
46	4	0.6
47	7	1.1
48	6	1.0
49	5	0.8
50	12	1.9
51	2	0.3
52	6	1.0
53	2	0.3
54	3	0.5
55	11	1.8
56	4	0.6
57	6	1.0
58	1	0.2
59	3	0.5
Total	619	100.0

Table: 3 shows the age wise distribution of cases taken up for study starting from 18 years up to 59 years without omitting even a single year of age progression.

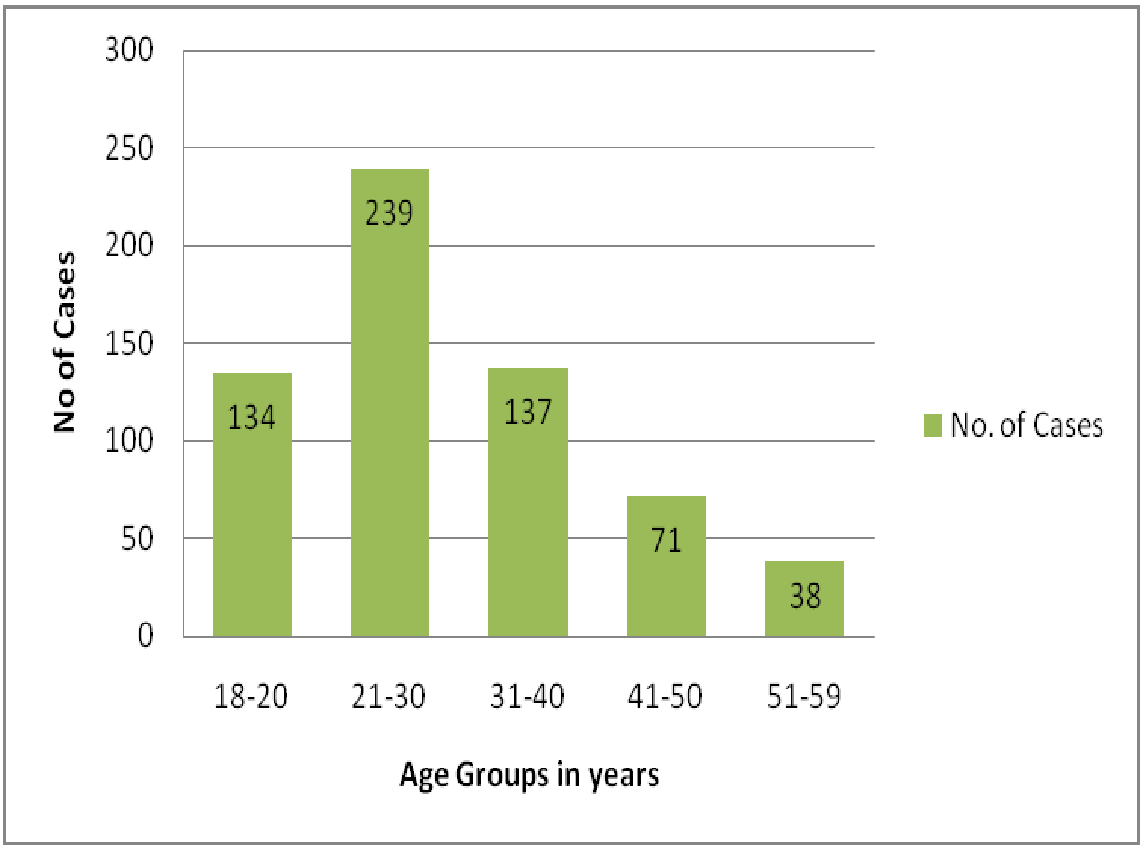
While taking into consideration the age distribution of the study sample, individuals who have not completed 18 years were deliberately excluded since the process of fusion and growth of long bones would not have got completed. Cases above 18 years of age alone were taken up for study since individuals of this age and above would have attained the maximum stature by that time. Likewise individuals who have completed 60 years of age and above were also excluded due to the reason that their stature decreases significantly because of osteoporosis and senile changes.

The age wise distribution of cases which includes both males and females were grouped together under 5 broad categories as in the table: 4 & figure 2.

Table: 4 Age group wise distribution of the study sample.

Sl. No.	Age distribution	No. of cases	Percentage
1	Age from 18 – 20 years	134	21.6
2	Age from21 – 30 years	236	38.7
3	Age from31 – 40 years	137	22.1
4	Age from41 – 50 years	71	11.5
5	Age from51 – 59 years	38	6.1
	Total	619	100.0

Figure: 2 – Age group wise distribution of the study sample.



The number of cases in the 18 – 20 years constitutes 21.6 % (134 Nos.) of the total sample size. Likewise in the 21 – 30 years category, the cases were 38.7% (239 Nos.) and in the 31 – 40 years category the cases were 22.1 % (137 Nos.) of the total sample size.

In the other two categories of 41 – 50 years and 51 – 59 years the number of cases studied were 71 (11.5%) and 38 (6.1%) respectively.

Since the ossification and growth of bones are in a stage of near completion at 18 – 20 years, the stature attained its maximum at this stage and it will be static for the next 10 years followed by a very negligible reduction in stature for the next 2 decades, more number of cases were taken into consideration in the age group of 18 – 20 years and also in the 21 – 30 years categories. This constitutes 60.3% (370 Nos.) of total sample size. The stature reduction will be progressive and more during the 6^{th} decade of life and hence only 38 cases were taken up for assessment.

As per the various references and studies carried out it has been proved that the stature gets reduced by 0.6 -1 mm per year of life starting from 30 years upto life time. Hence due care has been taken to reduce the sample size gradually starting from 4^{th} to 6^{th} decade.

All the cases studied were Indian nationals. The religious distribution of the sample is given in table: 5 and Figure: 3

Table: 5 Distribution of the study sample by religion.

Sl. No.	Religion	Frequency	Percentage
1.	Hindu	546	88.2
2.	Christian	41	6.6
3.	Muslim	32	5.2
	Total	619	100.0

Figure : 3 Distribution of the study sample by religion.

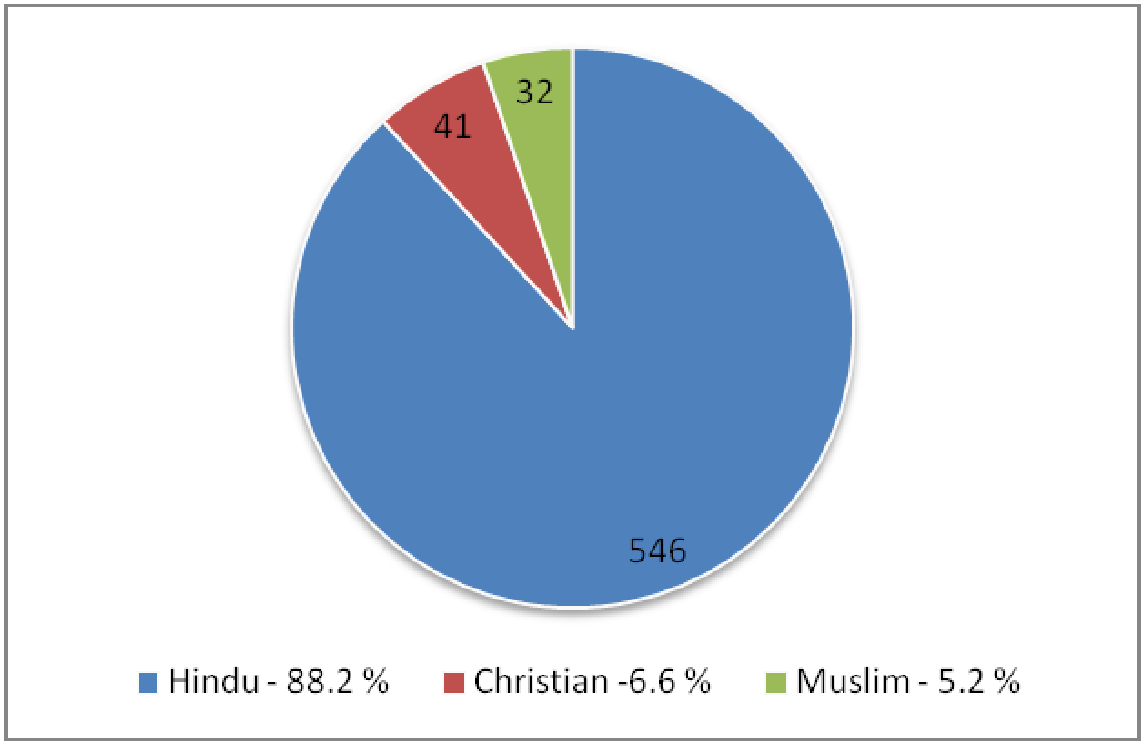
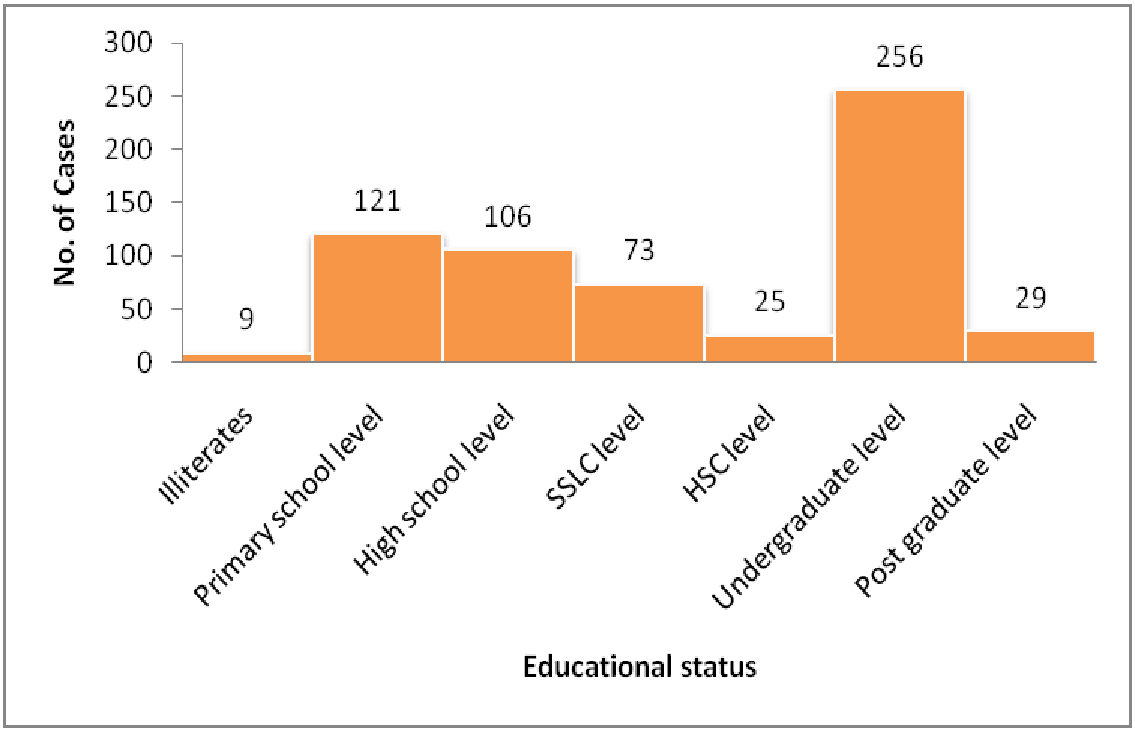


Table: 6 Education wise distribution of the study sample.

Sl. No.	Educational Status	No. of Subjects	Percentage
1	Illiterates	9	1.5
2	Primary school level	121	19.5
3	High school level	106	17.1
4	SSLC level	73	11.8
5	HSC level	25	4
6	Undergraduate level	256	41.4
7	Post graduate level	29	4.7
	Total	619	100.0

Figure: 4 Education wise distribution of the study sample.



The educational status of study sample consists of mostly medical students undergoing either undergraduate degree or post graduate courses in this college. The case distribution based on the educational qualification is given in the pervious table: 6 & figure: 4

Occupational status of the study sample was assessed and grouped in the following table: 7

Table: 7 Occupational wise distribution of the study sample.

Sl. No.	Occupation	No. of Cases	Percentage
1	Dependents	11	1.8
2	Students	229	37
3	Unskilled workers	85	13.7
4	Skilled workers	53	8.6
5	Home makers	147	23.7
6	Office Assistants	13	2.1
7	Government employees	16	2.6
8	Teachers	7	1.1
9	Nurses	2	0.3
10	Engineers	2	0.3
11	Doctors	27	4.4

All the data of the study sample were analyzed by applying mean, standard deviation, range, correlation coefficient for the selected variables for both sexes and multiple and simple regression equations for estimation of stature from hand length and foot length were derived separately for males and females.

Table: 8 Mean and standard deviation and range of the selected variables of the study sample and comparison between both sexes.

Selected variables in cm	Male				Female				Comparison	
	Mean	S.D.	Range		Mean	S.D.	Range		't' value	'p' value
			Min.	Max.			Min.	Max.		
Stature	167.455	7.213	146.1	190.0	154.106	6.389	139.6	178.0	24.364	<0.001
RHL	18.748	0.922	16.2	21.4	17.253	0.792	15.1	19.6	21.630	<0.001
LHL	18.892	0.914	16.5	21.6	17.291	0.781	15.0	19.2	23.430	<0.001
RFL	25.332	1.327	21.3	30.4	23.073	1.144	19.6	26.3	22.675	<0.001
LFL	25.410	1.299	21.8	30.3	23.091	1.127	19.6	26.4	23.711	<0.001

Table: 8 Shows mean, standard deviation and the range of the selected variables for adult males and females.

The average of stature for male adults is 167.5 cm with standard deviation of 7.2 cm and in cases of adult females it was 154.1 cm with standard deviation of 6.4 cm. The height range for male adults extents from 146.1 cm to 190.0 cm. In case of female adults it extents from 139.6 cm. to 178.0 cm.

The average right hand length for males is found to be 18.7 cm with standard deviation of 0.9 cm and in females it was 17.3 cm with standard deviation of 0.8 cm. The right hand length of male adults ranging from 16.2 cm to 21.4 cm. In case of female adults it ranges from 15.1 cm to 19.6 cm.

The average left hand length for males is found to be 18.9 cm with standard deviation of 0.9 cm and in females it was 17.3 cm with standard deviation of 0.8 cm. The left hand length of male adults ranging from 16.5 cm to 21.6 cm. In case of female adults it ranges from 15.0 cm to 19.2 cm.

The average right foot length for males is found to be 25.3 cm with standard deviation of 1.3 cm and in females it was 23.1 cm with standard deviation of 1.1 cm. The right foot length of male adults ranging from 21.3 cm to 30.4 cm. In case of female adults it ranges from 19.6 cm to 26.3 cm.

The average left foot length for males is found to be 25.4 cm with standard deviation of 1.3 cm and in females it was 23.1 cm with standard deviation of 1.1 cm. The left foot length of male adults ranging from 21.8 cm to 30.3 cm. In case of female adults it ranges from 19.6 cm to 26.4 cm.

The analysis of the said data clearly shows that there is no significant variation between hand length on both sides and foot length on both sides in case of males as well as in females. Student's 't' test was applied to compare the stature, RHL, LHL, RFL, LFL in both sexes. The result indicates there is a significant difference in all the selected variables namely, 1. Stature, 2. Right hand length, 3. Left hand length, 4. Right foot length, 5. Left foot length in which males are having higher values than females. It is because in general male individuals are having 1-2 years of extended growth period than in female individuals which results in longer and heavier bones, increase in stature and other dimensions of body parts.

Table: 9 Correlation co-efficient of the selected variables for male

Variables	RHL in cm.	LHL in cm.	RFL in cm.	LFL in cm.
Stature in cm	0.745**	0.728**	0.746**	0.763**
RHL in cm.	-	0.959**	0.807**	0.822**
LHL in cm	0.959**	-	0.813**	0.822**
RFL in cm	0.807**	0.813**	-	0.969**
LFL in cm	0.822**	0.822**	0.969**	-

** - P < 0.01

Table: 9 represents Pearson correlation coefficient of the selected variables for males. The correlation coefficient between the stature and other variables as follows:

Stature and right hand length - 0.745 ('r' value at 'p' < 0.01 level)

Stature and left hand length - 0.728 ('r' value at 'p' < 0.01 level)

Stature and right foot length - 0.746 ('r' value at 'p' < 0.01 level)

Stature and left foot length - 0.763 ('r' value at 'p' < 0.01 level)

This clearly shows that these are statistically highly significant. Moreover there is a positive correlation between stature and other selected variables. For example right hand length increases proportionately while the stature of person increases and vice versa. This applies to all other parameters also.

Table: 10 Correlation co-efficient of the selected variables for female

Variables	RHL in cm.	LHL in cm.	RFL in cm.	LFL in cm.
Stature in cm.	0.670**	0.650**	0.686**	0.665**
RHL in cm.	-	0.958**	0.783**	0.763**
LHL in cm.	0.958**	-	0.779**	0.756**
RFL in cm.	0.783**	0.779**	-	0.957**
LFL in cm.	0.763**	0.756**	0.957**	-

** - P < 0.01

Table: 10 represents Pearson correlation coefficient of the selected variables for females. The correlation coefficient between the stature and other variables as follows:

Stature and right hand length - 0.670 (‘r’ value at ‘p’ < 0.01 level)

Stature and left hand length - 0.650 (‘r’ value at ‘p’ < 0.01 level)

Stature and right foot length - 0.686 (‘r’ value at ‘p’ < 0.01 level)

Stature and left foot length - 0.665 (‘r’ value at ‘p’ < 0.01 level)

This clearly shows that these are statistically highly significant. Moreover there is a positive correlation between stature and other selected variables. For example left hand length increases proportionately while the stature of person increases and vice versa. This applies to all other parameters also.

Table: 11 Multiple and simple regressions equation for estimation of stature from hand length and foot length in males

Sl. No.	Independent Variables	Equations	SEE	R	R^2
1.	RHL, LHL, RFL, LFL	S = 48.87 + 0.299 (RFL) + 2.314 (LFL) + 3.072 (RHL) – 0.284 (LHL)	4.443	0.791	0.626
2.	RHL, RFL	S = 50.134 + 2.262 (RFL) + 3.202 (RHL)	4.487	0.785	0.616
3.	LHL, LFL	S = 49.489 + 2.441 (LHL) + 2.827 (LFL)	4.497	0.783	0.614
4.	RFL, LHL	S = 51.448 + 2.810 (LHL) + 2.484 (RFL)	4.576	0.775	0.600
5.	LFL, RHL	S = 48.644 + 2.839 (RHL) + 2.582 (LFL)	4.429	0.791	0.625
6.	RHL	S = 58.161 + 5.830 (RHL)	4.818	0.745	0.555
7.	LHL	S = 58.940 + 5.744 (LHL)	4.956	0.728	0.529
8.	RFL	S = 64.671 + 4.057 (RFL)	4.807	0.746	0.557
9.	LFL	S = 59.766 + 4.238 (LFL)	4.667	0.763	0.583

Table : 11 shows the multiple and simple regression equations between the stature of male adults and selected variables i.e. right hand length, left hand length, right foot length and left foot length. The stature of the adult male was estimated by 9 different regression equations.

★ 1) If all the 4 measurements namely right hand length, right foot length, left hand length and left foot length are known the stature of the adult male person estimated by **regression equation No.1.**

S = 48.87 + 0.299 (RFL) + 2.314 (LFL) + 3.072 (RHL) -- 0.284(LHL) ± 4.443

The multiple correlation coefficient between stature and all the 4 independent variables among adult males was found to be 0.791 (R value), which is statistically significant at P less than 0.01 level.

The corresponding R^2 (0.626) indicates that the stature was explained correctly by this 4 variables in 62.6 % cases. In other words if we know all the 4 measurements 62.6^ of times of our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 2) If the two measurements on right side namely right hand length and right foot length are known the stature of the adult male person is estimated by **regression equation No.2.**

Stature = 50.134 + 2.262 (RFL) + 3.202 (RHL) ± 4.487

The correlation coefficient between stature and the two independent variables i.e. right hand length and right foot length was found to be 0.785 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.616) indicate that the stature was explained correctly by

this two variables in 61.6% cases. In other words if we know the two measurements on right side, 61.6% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 3) If the two measurements on left side namely left hand length and left foot length are known the stature of the adult male person is estimated by **regression equation No.3.**

Stature = 49.489 + 2.441 (LHL) + 2.827 (LFL) ± 4.497

The correlation coefficient between stature and the two independent variables i.e. left hand length and left foot length was found to be 0.783 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.614) indicates that the stature was explained correctly by this two variables in 61.4 % cases. In other words if we know the measurement on left side, 61.4% times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 4) If the two measurements namely right foot length and left hand length are known the stature of the adult male person is estimated by **regression equation No.4.**

Stature = 51.448 + 2.810 (LHL) + 2.484 (RFL) ± 4.576.

The correlation coefficient between stature and the independent variables i.e. left hand length and right foot length was found to be 0.775 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.600) indicates that the stature was explained correctly by this two variables in 60% cases, In other words if we know the left hand length

and right foot length measurements, 60% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 5) If the two measurements namely right hand length and left foot length are known the stature of the adult male person is estimated by **regression equation No.5.**

Stature = 48.664 + 2.839 (RHL) + 2.582 (LFL) ± 4.429.

The correlation coefficient between stature and the independent variables i.e. right hand length and left foot length was found to be 0.791 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.625) indicates that the stature was explained correctly by this two variables in 62.5% cases, In other words if we know the right hand length and left foot length measurements, 62.5% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 6) If the length of right hand alone known the stature of the adult male person is estimates by **regression equation No.6.**

Stature = 58.161 + 5.830 (RHL) ± 4.818

The correlation coefficient between the stature and right hand length was found to be 0.745 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.555), indicates that the stature was explained correctly by right hand length in 55.5% cases. In other words if we know the measurement of right hand length, 55.5% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 7) If the length of left hand alone known the stature of the adult male person is estimates by **regression equation No.7.**

Stature = 58.940 + 5.744 (LHL) ± 4.956

The correlation coefficient between the stature and left hand length was found to be 0.728 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.529), indicates that the stature was explained correctly by left hand length in 52.9% cases. In other words if we know the measurement of left hand length, 52.9% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 8) If the length of right foot alone known the stature of the adult male person is estimates by **regression equation No.8.**

Stature = 64.671 + 4.057(RFL) ± 4.807

The correlation coefficient between the stature and right foot length was found to be 0.746 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.557), indicates that the stature was explained correctly by right foot length in 55.7% cases. In other words if we know the measurement of right foot length, 55.7% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

★ 9) If the length of left foot alone known the stature of the adult male person is estimates by **regression equation No.9.**

Stature = 59.766 + 4.238 (LFL) ± 4.667

The correlation coefficient between the stature and left foot length was found to be 0.763 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.583), indicates that the stature was explained correctly by left foot length in 58.3% cases. In other words if we know the measurement of left foot length, 58.3% of times our prediction of stature estimation exactly matches with the actual stature of the male person.

Table: 12 Multiple and simple regressions equation for estimation of stature from hand length and foot length in females

S. No.	Independent Variables	Equations	SEE	R	R^2
1.	RHL, LHL, RFL, LFL	S = 52.677 + 2.148 (RFL) + 0.235 (LFL) + 3.109 (RHL) - 0.416 (LHL)	4.470	0.719	0.517
2.	RHL, RFL	S = 52.601 + 2.341 (RFL) + 2.299 (RHL)	4.457	0.719	0.516
3.	LHL, LFL	S = 52.562 + 2.802 (LHL) + 2.299 (LFL)	4.566	0.702	0.492
4.	RFL, LHL	S = 53.712 + 2.384 (LHL) + 2.564 (RFL)	4.511	0.710	0.505
5.	LFL, RHL	S = 51.813 + 3.133 (RHL) + 2.089 (LFL)	4.508	0.711	0.505
6.	RHL	60.932 + 5.401 (RHL)	4.753	0.670	0.448
7.	LHL	62.268 + 5.311 (LHL)	4.865	0.650	0.422
8.	RFL	65.654 + 3.834 (RFL)	4.653	0.686	0.471
9.	LFL	67.101 + 3.768 (LFL)	4.779	0.665	0.442

Table: 12 shows the multiple and simple regression equation between the stature of female adults and selected variables i.e. right hand length, left hand

length, right foot length and left foot length. The stature of the adult female was estimated by 9 different regression equations.

★ 1) If all the 4 measurements namely right hand length, right foot length, left hand length and left foot length are known the stature of the adult female person estimated by **regression equation No.1.**

S = 52.677 + 2.148 (RFL) + 0.235 (LFL) + 3.109 (RHL) - 0.416 (LHL) ± 4.470

The multiple correlation coefficient between stature and all the 4 independent variables among adult females was found to be 0.719 (R value), which is statistically significant at P less than 0.01 level.

The corresponding R^2 (0.517) indicates that the stature was explained correctly by this 4 variables in 51.7% cases. In other words if we know all the 4 measurements 51.7% of times of our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 2) If the two measurements on right side namely right hand length and right foot length are known the stature of the adult female person is estimated by **regression equation No.2.**

Stature = 52.601+ 2.341 (RFL) + 2.299 (RHL) ± 4.457

The correlation coefficient between stature and the two independent variables i.e. right hand length and right foot length was found to be 0.719 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.516) indicate that the stature was explained correctly by this two variables in 51.6% cases. In other words if we know the two

measurements on right side, 51.6% of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 3) If the two measurements on left side namely left hand length and left foot length are known the stature of the adult female person is estimated by **regression equation No.3.**

Stature = 52.562 + 2.802 (LHL) + 2.299 (LFL) ± 4.566

The correlation coefficient between stature and the two independent variables i.e. left hand length and left foot length was found to be 0.702 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.492) indicates that the stature was explained correctly by this two variables in 49.2 % cases. In other words if we know the measurement on left side, 49.2% times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 4) If the two measurements namely right foot length and left hand length are known the stature of the adult female person is estimated by **regression equation No.4.**

Stature = 53.712 + 2.384 (LHL) + 2.564 (RFL) ± 4.511.

The correlation coefficient between stature and the independent variables i.e. left hand length and right foot length was found to be 0.710 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.505) indicates that the stature was explained correctly by this two variables in 50.5% cases, In other words if we know the left hand length and right foot length

measurements, 50.5 % of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 5) If the two measurements namely right hand length and left foot length are known the stature of the adult female person is estimated by **regression equation No.5.**

Stature = 51.813 + 3.133 (RHL) + 2.089 (LFL) ± 4.508.

The correlation coefficient between stature and the independent variables i.e. right hand length and left foot length was found to be 0.711 (R value), which is statistically significant at P less than 0.01 level. The corresponding R^2 (0.505) indicates that the stature was explained correctly by this two variables in 50.5 % cases, In other words if we know the right hand length and left foot length measurements, 50.5 % of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 6) If the length of right hand alone known the stature of the adult female person is estimates by **regression equation No.6.**

Stature = 60.932 + 5.401 (RHL) ± 4.753

The correlation coefficient between the stature and right hand length was found to be 0.670 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.448), indicates that the stature was explained correctly by right hand length in 44.8 % cases. In other words if we know the measurement of right hand length, 44.8 % of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 7) If the length of left hand alone known the stature of the adult female person is estimates by **regression equation No.7.**

Stature = 62.268 + 5.311 (LHL) ± 4.865

The correlation coefficient between the stature and left hand length was found to be 0.650 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.422), indicates that the stature was explained correctly by left hand length in 42.2% cases. In other words if we know the measurement of left hand length, 42.2 % of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 8) If the length of right foot alone known the stature of the adult female person is estimates by **regression equation No.8.**

Stature = 65.654 + 3.834 (RFL) ± 4.653

The correlation coefficient between the stature and right foot length was found to be 0.686 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.471), indicates that the stature was explained correctly by right foot length in 47.1 % cases. In other words if we know the measurement of right foot length, 47.1 % of times our prediction of stature estimation exactly matches with the actual stature of the female person.

★ 9) If the length of left foot alone known the stature of the adult female person is estimates by **regression equation No.9.**

Stature = 67.101 + 3.768 (LFL) ± 4.779

The correlation coefficient between the stature and left foot length was found to be 0.665 (R value) which is statistically significant at P less that 0.01 level. The corresponding R^2 (0.442), indicates that the stature was explained correctly by left foot length in 44.2% cases. In other words if we know the measurement of left foot length, 44.2% of times our prediction of stature estimation exactly matches with the actual stature of the female person.

In general if we know more than one measurements i.e. all 4 measurements or ipsilateral hand and foot measurements or contralateral hand and foot measurements, the prediction validity of the estimation of the stature of the person was higher compared to prediction validity of the estimation of the stature of the person from a any single measurement alone.

Table 13: multiplication factors for stature estimation from hand length and foot length of both sides in both sexes

Selected Variables	Male	Female
Right hand length	8.93	8.93
Left hand length	8.86	8.91
Right foot length	6.61	6.68
Left foot length	6.59	6.67

The table: 13 shows the estimation of stature by applying multiplication factors with each selected variables for both males and females. There is no significant variation in the multiplication factors for males and females in stature estimation.

The multiplication factor for stature estimation with right hand length is 8.93 for both males and females. The multiplication factor for stature estimation with left hand length is 8.86 in males and 8.91 in females.

The stature of an individual is 6.61 times of Right foot length in case of males and 6.68 times in case of females. The stature of an individual is 6.59 times of left foot length in case of males and 6.67 times in case of females.

Conclusion

SECTION - VI

CONCLUSION

In this cross sectional study, 619 cases ranging from 18 to 59 years of this region were studied for stature and its relevance with that of hand length, foot length on either side in both males and females. Multiple regression equations were derived by using all the four parameters for estimation of stature of an individual for either sex separately.

Likewise multiple regression equations for stature estimation were found out taking into consideration the hand and foot length on the ipsilateral side and also for the contralateral combinations for both sexes (by using only two parameters, i.e. any hand + any foot).

In the same way simple regression formulas were worked out separately for hand and foot to estimate the stature from right side as well as left side for both sexes.

Multiplication factors for stature estimation were worked out separately for both males and females with each selected variables.

1) Stature estimation is relatively more accurate in males compared to females. It might be due to high variation in the attainment of puberty and unpredictable age of menopause in women.

2) The values of selected variables derived for left side of the body appears to be slightly more compared to the right side in both sexes. It might be due to the fact that the right side may have undergone some changes due to the extra work done by the right limbs.

3) The stature estimation will be more precise and accurate if we get measurements of both hands and feet of an individual with standard error of estimate of 4.443 cm. in case of males. In females this standard error of estimate is 4.470 cm.

4) Stature estimation from measurement of any combination of hand and foot (RH & RF; LH & LF, RH & LF; LH & RF) will give almost the same results as that of using all the four parameters together (RHL, LHL, RFL, LFL). In this standard error of estimate for males ranging from 4.429 cm to 4.497 and for females ranging from 4.457 to 4.566 cm.

5) If any one of the foot length measurement is available the stature estimation will be with SEE of 4.667 to 4.807 cm in males and 4.653 to 4.779 in female cases.

6) If any one of the hand length measurement alone available the stature estimate will be with SEE of 4.818 to 4.956 cm in males whereas in females it is 4.753 to 4.865 cm.

7) If the measurement of any one variable alone is available the stature estimation will be good if it is foot rather than hand.

8) There is no significant variation in multiplication factors for males and females in stature estimation. Multiplication factor for male hand is 8.90 and for female hand it is 8.92. The stature of an individual is 6.60 times male foot and 6.68 times of female foot.

Summary

SECTION – VII

SUMMARY

Estimation of stature from dismembered body parts assumes great significance and interest in the field of forensic anthropology.

Stature prediction will be more accurate, when we use combination of any hand length and foot length, for calculation by regression formulas. However it can also be estimated if any one of the parameter is available. It is always more preferable if we get the foot length than hand length. While calculating stature by regression formula method, the results are relatively more precise in males rather than in females.

There is no significant variation in the multiplication factors in case of males and females while estimating stature using hand length and foot length.

To conclude, since this study gives statistically highly significant values, stature estimation in this regional population can be more accurately calculated by applying these regression equations and multiplication factors.

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Appendices

DETAILS OF STUDY PROTOCOL

1. **TITLE** : Stature estimation from Hand length and Foot length in adults – A regional study in Chennai, Tamilnadu.

2. **STUDY OBJECTIVES**:

    a. To find the correlation between Hand length, Foot length with stature in an adult individual and deriving simple and multiple regression equations for stature estimation for both sexes.

    b. To find out the multiplication factors for hand length and for foot length to estimate the stature in both sexes separately.

3. **DESIGN OF STUDY:** Descriptive cross sectional study.

4. **PERIOD OF STUDY**: 9 months from January 2007 to September 2007.

5. **ETHICAL CLEARANCE**: Ethical clearance obtained.

6. **CONSENT**: An informed written consent will be obtained from subjects/participants.

7. **SELECTION OF STUDY SUBJECTS**:

    Inclusion criteria: Willing healthy adult individuals of both sexes from medicine OP and medicine wards between 18 to 59 years of age.

    Exclusion criteria:

a. Subjects less than 18 years

b. Subjects more than 59 years

c. Subjects with spinal deformities

d. Subjects with injuries to hand

e. Subjects with injuries to foot

f. Subjects with any major systemic diseases

g. Subjects with endocrine disorders

h. Pregnant women and lactating mothers

i. Unwilling individuals

8. **DATA COLLECTION**:

a. General particulars like Name, Age, Sex, Address, Religion, Education, Occupation etc.,

b. Height in cm.

c. Right hand length in cm.

d. Left hand length in cm.

e. Right foot length in cm.

f. Left foot length in cm.

9. TOOLS:

a. Wooden Height measuring stand having measurement of 0-195 cm. with mm. accuracy.

b. Wooden osteometric board with a fixed 30 cm. long metal scale having measurement of 0-30 cm. with mm. accuracy.

c. One foot metal scale / sliding caliber.

10. **METHODS**:

a. Height of the subject measured between sole to top of head while he stands erect with feet together on a wooden height stand, having calibrated vertical wooden rod (0-195 cm.) fixed with a platform at base to stand on and a horizontal sliding wooden bar movable from top to bottom and can be fixed at the noted height.

b. Hand length measured by a sliding caliper from mid point of most distal flexing wrist crease to tip of the middle finger.

c. Foot length is measurement by an osteometric board from back of heel to tip of either great toe or second toe whichever is protruding most.

11. **ANALYSIS**: Appropriate statistical analysis.

12. **PRINCIPAL INVESTIGATOR**:

Dr.K.S.M.VENKATACHALAM

M.D. Post Graduate student in Forensic Medicine.

13. **GUIDES**:

- Dr. R. VALLINAYAKAM, Director and Professor of Forensic Medicine
- Dr. P. RAVISANKAR, Additional Professor of Forensic Medicine.
- Dr. R. SELVAKUMAR, Reader in Forensic Medicine.
- Dr. N. SRINIVASA RAGAVAN, Assistant Professor of Forensic Medicine
- Dr. THIRUMALAIKOLUNDU SUBRAMANIAN, Director and Professor of Internal Medicine.

PROFORMA

Serial No :……. Date :……/……../2007

Name :……. Sex : Male / Female

Date of Birth as stated by the subject :…….

Age :…….. in completed years.

Religion : ……

Address :……..

……

……

Educational Qualification:……

Occupation :……..

Income : Rs……../ per month.

Height :……. in cm.

Right Hand Length :……. in cm.

Left Hand Length :……. in cm.

Right Foot Length :…….. in cm.

Left Foot Length :…….. in cm.